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THE SPRING MEETING

The Spring Meeting was held at Cleveland, Ohio, May 28 to 31, with a total registration of 562, of whom 221 were members. The headquarters during the meeting were at the Chamber of Commerce Building, where the professional sessions and several of the social functions were held, and lunches were served there on Wednesday and Friday. This building is well adapted for a gathering of this kind, and especially so in this case, as it is the home of the Cleveland Engineering Society, whose rooms were freely thrown open to the use of the members.

The Committee on Meetings, Dr. Charles E. Lucke, Chairman, had arranged a strong professional program, and the Local Committee under the chairmanship of Ambrose Swasey contributed in every possible way to the pleasure of the members and their guests. His efforts were ably seconded by those of Prof. Robert H. Fernald, Vice-Chairman, F. W. Ballard, Secretary, and R. B. Sheridan, Treasurer. The Local Committee was divided into several special committees, the Citizens Committee being headed by Mr. Swasey, the Executive and Entertainment Committees by Professor Fernald, and the Finance Committee by Mr. Sheridan, Transportation by George E. Merryweather, and Accommodations by Arthur G. McKee. The chairman of the Ladies Committee was Mrs. Ambrose Swasey,

and the Vice-Chairman, Mrs. Robert H. Fernald. At the Friday morning session resolutions were passed expressing the thanks and appreciation of the visiting members for their entertainment, but a word more should be added here on behalf of the Secretary of the Society and the office staff, whose work was greatly facilitated by the effective organization of the Cleveland committees. Not only was the abundant and enjoyable entertainment provided for, but their painstaking care in attending to the minor details connected with the management of the meeting was an important factor in its success.

THE FIRST DAY OF THE MEETING

On the afternoon of Tuesday, the first registration day, Mr. and Mrs. Ambrose Swasey received the members and guests at their residence. This gathering, held under auspices so favorable and surroundings so attractive, afforded a most pleasing introduction to the events that were to follow.

Tuesday evening was of the nature of a diversion from the more serious technical sessions of the succeeding days. Cleveland boasts one of the most skillful cartoonists in the country, J. H. Donahey of the *Cleveland Plain Dealer*, whose services were enlisted for the evening. Mr. Donahey is also a "lightning" sketch artist, and he made a series of crayon sketches before the audience on large sheets of paper. Several of these were caricatures of well-known people, and likenesses were drawn of President Humphreys, Ambrose Swasey, and Secretary Rice. Mr. Donahey had as running-mate the city editor of the *Plain Dealer*, W. R. Rose, who entertained the audience with stories while the sketches were in process.

ADDRESSES OF WELCOME

The session on Wednesday morning opened with a greeting by Mr. Swasey on behalf of himself as a member and as chairman of the local committee, and of the Cleveland members generally. He recalled that it was 29 years ago when the Society last met in Cleveland—a long time to wait for a second visit. The Society then numbered about 400 members, while today it has more than 4000. Not only has it grown in membership, but it has broadened its scope in every direction of mechanical engineering, covering new fields of science which were scarcely dreamed of when the Society met before in this city.

Many members would have gladly attended this convention, who,

for one reason or another, were unable to do so. Mr. Swasey had with him several letters sent to the local committee by absent members and read abstracts from some of the letters which came from past-presidents of the Society. One was from John E. Sweet, "the father of The American Society of Mechanical Engineers," who, said the speaker, should he live until October 21, would be 80 years of age; but "we know him to be of good courage, for on the day when he was 79, he and Mrs. Sweet started on a journey around the world, which was completed successfully."

Another letter was from E. D. Leavitt, who was president of the Society when it met in Cleveland 29 years ago. Still another was from John Fritz, whom they love to call "Dear old Uncle John," and who on August 21 next will be 90 years of age.

There were present on the platform at this opening session past-presidents George Westinghouse, E. D. Meier, Ambrose Swasey, S. T. Wellman and Jesse Smith, besides President Humphreys, and herewith are given extracts from letters received from other past-presidents who were unable to be present.

John E. Sweet wrote that he was not well, but that "the doctor has guessed at the right remedy. The idea of getting the past-presidents together is a nice thought, and I hope they will all be there except your humble servant."

E. D. Leavitt: "Eight years of continuous ill health precludes attendance at conventions and compels a quiet life. Please give my heartiest greetings to the members."

Henry R. Towne: "Permit me to compliment the local committee on its wisdom in planning to secure the attendance of as many as possible of the past-presidents. I had some share in initiating the plan under which the past-presidents become members of the council, and have always believed that the Society was greatly benefited and strengthened by thus retaining the influence and council of those who have served it in a presidential capacity."

John R. Freeman: "I have extremely pleasant memories of Cleveland dating away back to the first meeting of our Society in your city, and to an exhibition of an observatory live ring at the then modest shops of Warner and Swasey."

Oberlin Smith: "Heartiest greetings to the members of our beloved Society; would I were there."

John Fritz, who at present is confined to his room through ill health, expressed the wish that he could again meet the members of the various engineering societies with whom he has been so intimately associated for so many years, and asked through his Secretary "that his kindest greetings be extended to all dear friends assembled."

Fred. R. Hutton: "I send this greeting and sentiment based on the initials of the Society's name. May the initials A. S. M. E. stand also in the future as in the past for organization Always Sane, Majestic, Energetic.

"*Always*, with a permanence of wise policy in its management; *Sane*, undisturbed by fevers and the delirium of the newest untried dope of the demagogue;

Majestic, because, conscious of its power and its responsibility, its stored energy is irresistible; *Energetic*, because it is always moving in progress toward its goal of pre-eminence."

Notes of regret were also received from Past-Presidents Charles E. Billings, James M. Dodge and M. L. Holman.

Mr. Swasey then introduced Newton D. Baker, mayor of Cleveland.

ADDRESS OF MAYOR BAKER

Newton D. Baker, mayor of Cleveland, on behalf of the City, welcomed the Society in an address which was a model of its kind. He said in part that he could well understand the surprised inquiry of an ancient population when they asked, "Is Saul among the prophets?" for he discovered himself in an attitude which was certainly as unfamiliar as prophecy could have been to Saul. The idea of a mayor being in the company of so many eminent and distinguished engineers presented an anomaly that nothing but the accidents of political fortune could possibly explain. Perhaps, however, since the profession to which engineers devoted their lives was the business of directing the energy of and producing results from machinery, it was not so wholly inappropriate that a man who occasionally dipped into political endeavor should be among them, and yet he hardly deemed himself worthy on that ground alone to be a member of that distinguished company.

In commenting on a statement attributed to Dr. Humphreys, that the age of the poor genius had passed, that the geniuses of the future were going to be rich, he said he was enabled to congratulate them all heartily, but that it did not afford him any particular personal satisfaction.

Engineers represent one of the greatest departments of human knowledge and human endeavor. The mapping out of the activities of mankind that has gone on in the last hundred years, the last fifty years even more markedly, has set aside out of the great domain which the human intellect could hope to conquer, special provinces for special men. But in the mechanical arts, the application of the great forces of nature to machinery, the advance has been the wonder of the world. The only aspect that occurred to him as appropriate for him to consider or to suggest for the consideration of those present was whether or not the economic aspects of their activities have really been as progressive as the scientific and mechanical aspects; has the benefit that ought to have come to the human race

from these marvellous inventions and this increased knowledge been as widespread as it ought to be? He felt that unless the economic aspects, the processes of distribution, the economic aspects of the advance of mankind keep pace with the conquering hand that reduces the forces of nature to better subjection, an unstable civilization will result.

He took a very solid satisfaction from the statement that the poor genius is a thing of the past; because it seemed to him that the man who had the genius to conceive and fabricate the wonderfully interesting and complicated and intricate and wonderfully productive things that were now made in response to the suggestion and the touch of men like those present, men who had the genius to do that, if they are to be the participants in the benefits, if they are really to be controllers of the economic process as well as of the mechanical and industrial process, it will mean a wider distribution of the benefits of this advance of learning.

In concluding he said it was no part of his habit, no part of his taste to praise Cleveland, but he as mayor, in welcoming the Society, wished to characterize the thing of Cleveland which most appealed to those that lived there and of which they were most proud, and of which he wanted the Society to be the most conscious as Cleveland's message to it on its departure. He thought he could truthfully say that the general attitude of the people of Cleveland was a certain hospitality to new ideas, a certain generosity in its welcome to every man who comes to it with a message, to every man who comes to it bringing wisdom, to every man who comes to consult and confer for things that better the human race.

DR. HUMPHREYS' REPLY

In his reply, Dr. Humphreys was sorry to confess that he was not responsible for the statement attributed to him, but wished he had said it now that it had been turned so beautifully. He was delighted to have heard Mayor Baker speak as he did with regard to what he conceived to be the outlook of the engineer, for he had touched on a topic which was very close to his heart. He thought that the real growth of the Society was to be found, not in the increase in numbers, but in its growth in character and scope.

So many of the problems of the day which are troubling us in this country, and even threatening us, have to do with industrial problems, and certainly if there is any body of men that can help toward the solution of those problems it must be the educated engineers of

the United States. He agreed that they as a profession had not recognized that responsibility and that the day had come when they must recognize that they were not only engineers, but that they were citizens, and as such, carry a very great responsibility in connection with their citizenship because of the knowledge they have in regard to engineering matters, and consequently of industrial problems. For these reasons he considered that the politician and the engineer could not afford to work apart.

This ended the introductory remarks and the meeting proceeded to the order of business, President Humphreys presiding, the first item being the announcement by the Secretary of the reports of the Tellers, first on the recent vote on the amendment to the constitution, relating to the expenses of meetings and second on the election and promotion of members.

The amendment is as follows, which is to be inserted between the existing C 42 and C 43 of the constitution:

C 43 The expenses of all meetings of the Society and of any group or section thereof, shall be arranged in accordance with such By-Laws and Rules as the Council may from time to time adopt, provided, however, that nothing in this section shall be construed to authorize the Council to make any increase in the annual dues of members in any grade.

The summary of the membership ballot is as follows:

SUMMARY OF BALLOT

Members	196
Promotion to Members	37
Associates	5
Promotion to Associates	1
Juniors	125
Total	364

Jesse M. Smith, Past-President, at the request of the Council, then presented a report on several proposed amendments to the constitution. These amendments were suggested by the Committee on Increase of Membership and the Membership Committee to better provide for new members and make our Society uniform in its membership and method of election with sister engineering societies here and abroad. A new grade of membership is proposed to be known as Associate-Member, which is distinguished from the present Associate grade. As defined an Associate "shall be thirty years of age or over. He need not be an engineer, but must have been so connected with some branch of engineering or science

or the arts or industries that the Council will consider him qualified to coöperate with engineers in the advancement of professional knowledge." An Associate-Member "shall be an engineer or teacher of applied science of twenty-five years of age or over. He must show by his experience or by his duties that he is competent to execute work in his profession." It is further proposed to simplify the machinery of election of members by submission of the ballot to the Council only instead of to the membership at large.

In the discussion of this report, A. B. Carhart raised the point that confusion might result from having two grades of membership with names so nearly alike as the ones proposed of Associate and Associate-Member. Charles Whiting Baker believed there was serious objection to the proposal and suggested that the difficulty might be overcome by following the plan of some of the foreign societies, calling the youngest grade of members Student-Members, consisting of those from 21 to 25 years of age, and then adopting the term Junior-Member for the man between 25 and 30 who wants to come into the Society.

The full text of the proposed changes in the constitution will be submitted to the membership in letter-form 60 days before the December Annual Meeting for discussion at that time.

PROFESSIONAL SESSIONS

Following the business meeting came the first of the professional sessions, one being a continuation of the business meeting in the main auditorium and the other a meeting of the Gas Power Section, held in the Chamber of Commerce library. All the professional sessions were of interest, holding the attention of the audiences throughout, and were well attended.

In connection with this account is published a complete program of these sessions together with a list of those who took part in the discussion. Abstracts of the several papers with a complete report of the discussion will appear in later issues of The Journal. The papers themselves have already been published in The Journal in full.

WEDNESDAY AFTERNOON AND EVENING

On Wednesday afternoon there were definitely arranged eight excursions, as follows: American Steel & Wire Company, by special

train; Brown Hoisting Machinery Company; National Acme Manufacturing Company; Peerless Motor Company; Pennsylvania Railroad Ore Handling Plant; Warner and Swasey Company; White Company (automobiles); Winton Motor Carriage Company.

Everybody, both ladies and gentlemen, were further invited to the Cleveland Country Club, where tea was served. Many accepted and the trip was made by automobile in cars supplied by the Winton, Peerless and White companies. The drive to the Country Club takes one over several miles of the park system of Cleveland and is a delightful trip.

On Wednesday evening, Dr. Dayton C. Miller of Case School gave his lecture on Sound Waves. After the lecture expressions of commendation were heard on every hand. Dr. Miller's exposition of the subject was clear and clean cut and his demonstration of apparatus and slides thrown on the screen showing the characteristics of sound waves were of exceptional interest. An abstract of the lecture, given quite fully, is published elsewhere in this number.

THURSDAY'S ENTERTAINMENT

On Thursday the morning session adjourned at 11:30 in order to give everyone an opportunity to go on the afternoon excursion on Lake Erie by one of the boats of the Eastland Navigation Company. The boat was entirely at the disposal of the members and guests and the sail on the lake was most enjoyable and gave what was perhaps the best opportunity of the convention for meeting friends and renewing acquaintance.

On Thursday evening, the local members were at home at the Colonial Club where the visiting members and friends were received, and later in the evening there was the dance and collation which have regularly been enjoyable features both of the Annual and Spring Meetings.

FRIDAY'S EVENTS

The visiting members very generally stayed over until Friday evening, attending the session in the morning and the excursions in the afternoon. In fact, the Friday morning session brought out the most varied and interesting discussion of the entire meeting.

The excursion planned for the afternoon was by train to Akron, Ohio, where visits were made to the plants of the Goodrich Rubber Company and the Wellman-Seaver-Morgan Company.

At the conclusion of the discussion of papers on Friday morning, Prof. Arthur M. Greene offered the following resolution:

WHEREAS, the members and guests of The American Society of Mechanical Engineers assembled at the Semi-Annual Meeting in Cleveland, Ohio, May 28-31, 1912, have received the generous hospitality of the members of the Society in Cleveland and its vicinity, and have participated in the many social events arranged by the Local Committee:

BE IT RESOLVED, that on behalf of the visiting members and guests the Secretary extend the thanks of the Society to the Local Committee and to the Ladies Committee for the many provisions made for their pleasure and comfort in Cleveland; to Ambrose Swasey, Past-President, and Mrs. Swasey for the delightful reception in their home; to Messrs. J. W. Donahey and W. R. Rose of The Cleveland Plain Dealer, for their entertainment; to Dr. Dayton C. Miller of the Case School of Applied Science, for his instructive lecture on Sound Waves and the demonstration of the new instrument, the "Phonodeik"; to J. D. Rockefeller for opening his spacious and beautiful grounds; to the Cleveland Engineering Society for the use of their rooms; to the Cleveland Telephone Company for gratuitous service rendered; to the White, Peerless and Winton Automobile Companies for cars placed at the disposal of the visitors; and to the American Steel & Wire Company, the B. F. Goodrich Company, the Wellman-Seaver-Morgan Company, the Warner & Swasey Company, and other firms in Cleveland and vicinity, who generously opened their works for inspection by those in attendance at the Convention, or in certain cases supplied means of transportation and entertainment.

Past-President E. D. Meier then said that any resolution of this kind must necessarily be put into such short form that it seems almost perfunctory and that there was no one who had participated in the hospitality extended by the Cleveland friends but would feel that more was meant than the resolution actually said. "The expression of appreciation comes from our hearts; those who have had the pleasure of attending other conventions at Cleveland were prepared to expect a great deal, but their expectation has been outdone." He could only say that he hoped that at the Annual Meeting in New York as many Clevelanders as possible would honor the members there and give them a chance to reciprocate in a small way. Colonel Meier seconded the motion and suggested that it be adopted by a rising vote.

Secretary Rice expressed his thanks because, as he said, he had "had absolutely nothing to do, and such an opportunity is seldom given to a Secretary." It is always the aim at these conventions to have the ideal combination of a great variety of subjects presented by the best authorities in order to extend the scope and thought of every man and to give him an incentive; and then to provide in addition for the development of social acquaintanceship, all tending

to the greatest good of the profession. The latter part, the development of social acquaintanceship, had been magnificently provided for by the Cleveland members, and he wished to express every possible appreciation for the splendid work which Mr. Swasey and the Local Committee had accomplished.

The resolution was then passed unanimously and briefly acknowledged by Mr. Swasey for the Local Committee.

ENTERTAINMENT BY THE LADIES COMMITTEE

Through arrangements made by the Ladies Committee, the visiting ladies were invited to see as many points of interest about the city as their time allowed. On Wednesday morning they visited the plant of the H. Black Company, Cloak manufacturers, where processes of manufacture were inspected and garments were displayed on the company's models. Beside the trip by automobile to the Country Club, the ladies were taken through the spacious grounds of J. D. Rockefeller by automobile.

PRINTED MATTER

The printed matter issued by the Cleveland committee was exceptionally attractive and complete. A handsome souvenir of the Convention is "The Cleveland Book," containing 125 pages, bound in flexible cloth and printed on coated paper, with many illustrations. To quote the words of the title page, it contains "the program and particulars of the event together with an account of the leading participants in present and past meetings of the Society in Cleveland, and some discussion of the civic and manufacturing details that are of most consequence to mechanical engineers." No less than five past-presidents of the Society have been active in the affairs of Cleveland, and an account of their lives is given in the book. There is also much information about Cleveland and its various institutions.

A convenient vest-pocket booklet was issued containing a directory of plants with a description of the street car routes and time schedules in order to give visitors all possible aid in making the best use of their time during their stay in the city. A small map of the business section of Cleveland is included in this booklet.

An innovation in the way of printed matter was the issuance each day of the "A.S.M.E. Daily News," consisting of slips of cardboard of pocket size on which were printed a list of the events for the day and the hours at which they were to occur; including the professional sessions, entertainment features, excursions, etc. These slips were

a great convenience to the visitors and constituted a feature which may well be adopted at later meetings.

PROGRAM

OPENING SESSION

Tuesday Afternoon, May 28

Informal reception at the home of Mr. and Mrs. Swasey.

Tuesday Evening

Membership reunion and informal reception, Chamber of Commerce Hall.

SECOND SESSION

Wednesday Morning, May 29

Business Meeting: Reports of committees, tellers of election; new business.

A New Analysis of the Cylinder Performance of Reciprocating Engines, J. Paul Clayton.

Discussed by Arthur L. Rice, F. E. Cardullo, R. C. Stevens, S. A. Moss, R. C. H. Heck, F. W. Marquis, C. D. Young, J. B. Stanwood, W. D. Ennis.

Equipment of a Modern Flour Mill on a Gradual Reduction System, John F. Harrison and W. W. Nichols.

Design and Mechanical Features of the California Gold Dredge, Robert E. Cranston.

SIMULTANEOUS SESSION

GAS POWER SECTION

Problems in Natural Gas Engineering, Thomas R. Weymouth.

Bituminous Coal Producers for Power, C. M. Garland.

Discussed by O. P. Hood, E. D. Dreyfus, Leon B. Lent, N. A. Marsh, Thos. R. Weymouth, Chas. W. Baker.

Some Tests on Carbureters, George W. Munro.

Discussed by Mr. King, C. M. Garland, Professor Vose, R. C. Carpenter, George A. Orrok.

Wednesday Afternoon

Inspection by members of local manufacturing and power plants. Automobile trip for ladies through the parks. Tea served at the Country Club.

Wednesday Evening

Sound Waves: How to Photograph Them and What They Mean, Dr. Dayton C. Miller, of the Case School of Applied Science.

THIRD SESSION

Thursday Morning, May 30

New Processes for Chilling Cast Iron, Thos. D. West.

Tests of Chillable Irons, Thos. D. West.

Discussed by J. E. Johnson, Jr., H. M. Lane, Benjamin D. Fuller, Henry M. Howe, Henry Souther, P. Munnoch, Paul Kreuzpointner, James A. Beckett, Carl Hering, A. S. Dowler, C. B. Murray, Albert Sauveur, Bradley Stoughton, A. E. Outerbridge, Jr.

Strength of Steel Tubes, Pipes and Cylinders under Internal Fluid Pressure, Reid T. Stewart.

Discussed by C. N. Sames, T. A. Marsh.

On the Control of Surges in Water Conduits, Wm. F. Durand.

Speed Regulation in Hydroelectric Plants, Wm. F. Uhl.

Thursday Afternoon

Excursion on Lake Erie.

Thursday Evening

Reception and dance at Colonial Club.

FOURTH SESSION

Friday Morning, May 31

The Present State of Development of Large Steam Turbines, A. G. Christie.

Discussed by George A. Orrok, F. Hodgkinson, C. V. Kerr, J. A. Moyer, Clarence P. Crissey, E. D. Dreyfus, Carl Geo. deLaval, W. L. R. Emmet.

A Discussion of Certain Thermal Properties of Steam, G. A. Goodenough.

Discussed by F. E. Cardullo, H. N. Davis, R. C. H. Heck.

The Reduction in Temperature of Condensing Water Reservoirs due to Cooling Effect of Air and Evaporation, W. B. Ruggles.

Discussed by F. E. Cardullo, W. H. Carrier, W. T. Donnelly.

Results of Tests on the Discharge Capacity of Safety Valves, E. F. Miller and A. B. Carhart.

Friday Afternoon

Inspection of plants of The Goodrich Rubber Company, the Wellman-Seaver-Morgan Company at Akron, and the Diamond Match Company at Barberton.

SOUND WAVES

WHAT THEY MEAN AND HOW TO PHOTOGRAPH THEM

On Wednesday evening of the Spring Meeting an exceedingly interesting experimental lecture was given by Dr. Dayton C. Miller, professor of physics in Case School of Applied Science, on the subject of sound waves. The lecture culminated in the demonstration of an instrument invented by the speaker, known as the "phonodeik," by which the characteristics of sound waves are recorded on a photographic film. Many of these records were projected on the screen, and a demonstration was given of a large projection phonodeik by which a ray of light, reflected from a mirror caused to vibrate by sounds from various sources, is thrown on the screen in a way to show the characteristics of the sound waves produced.

In the production of sound the vibrations of the sounding body are transmitted to the ear, usually through the medium of the atmosphere. These vibrations produce in the surrounding air displacements, velocities, accelerations, changes of density, and other physical phenomena. These changes of density and other phenomena are propagated outwards in radial directions, with a velocity of about 1100 ft. per sec. Such disturbances as they exist in the air around a sounding body, constitute *sound waves.*

The only kind of vibration that can be propagated by the air is a longitudinal, or back-and-forth, movement as distinguished from a cross-wise or transverse movement. All that the ear perceives in the complex music of a symphony orchestra is contained in the wave-motion of the air which is completely represented by motion of one dimension, that is by motion in a straight line.

That motion in one dimension is capable of producing such sounds is simply proved by the telephone, the diaphragm of which can move only back-and-forth. The talking-machine is perhaps a better demonstration of the same fact.

The ear receives three classes of sensations from tones, and presumably no more. One of these gives rise to the characteristic of

the tone called pitch; this is easily proved to depend upon a very simple condition, that of mere frequency of vibration.

The second property of tone is loudness or intensity, which is not so simple as pitch. For tones of the same pitch, it varies mainly as the energy of vibration, and this is a function of the amplitude, varying approximately as its square; loudness also varies with pitch, approximately as the square of the frequency.

The third property of tone is much the most complicated; it is that characteristic of sounds produced from some particular instrument or voice, by which they are distinguished from the sounds of the same loudness and pitch, produced from other instruments or voices. This characteristic is called timbre, tone-color, or simply, *quality*.

When we inquire as to the cause of tone quality, since pitch depends upon frequency and loudness upon amplitude, we conclude that quality must depend upon the only remaining property of a periodic vibration, namely, the peculiar kind or form of the motion; or, if we represent the vibration by a curve or wave line, the quality is dependent upon the peculiarities represented by the shape of the wave. There is possible an endless variety of motion for the production of sound, and quality is, therefore, almost infinitely complicated in its causes, as compared with the other two properties of sounds.

As already stated, sound waves in air are longitudinal; in many solid bodies the motion producing and transmitting sound are transverse, as in the tuning-fork. It can readily be shown that both kinds of wave motion are correctly and adequately represented by the same type of line, the *harmonic curve*. The correctness of this statement is also shown by the talking-machine, the record for which is a *transverse* wavy line, which by the reproducing mechanism gives equivalent *longitudinal* movements to the diaphragm.

Tuning-forks properly constructed and mounted on resonance boxes are shown by analysis to produce vibrations in the air which are single simple harmonic motions; the resulting tones are called simple tones, and their sensation is markedly simple and pure. If several simple tones of different pitches, as from several tuning-forks, are simultaneously sounded, they simultaneously excite different systems of waves, which exist as variations in density of the air; the resulting displacements, velocities, and changes in density of the air are each equal to the algebraic sum of the corresponding displacements, velocities, and changes in density which each system

of waves would have separately produced had it acted independently. There must, therefore, be peculiarities in the motion of a single particle of air which differ for a single tone and for a combination of tones; and in fact the kind of motion during one period is entirely arbitrary, and may indeed be infinitely various. (A model was exhibited showing three simple waves, and their combinations in various phases.)

Every sound which has a distinct quality is a composite sound. Analysis has shown that the tone from a clarinet may have twenty-five or more components, the trombone thirty, and the piano as many as forty-two. Such tones are musically rich and full in quality and are usually much admired; though by way of contrast, simple tones are often considered very sweet. (An experiment was performed, compounding ten simple tones into one resultant tone, illustrating the composite character of the ideal musical tone.)

The method by which the ear proceeds in its analysis of tone quality was first definitely stated by Ohm, in Ohm's law of acoustics. Helmholtz states this law in the following form:

"Every motion of the air which corresponds to a composite mass of musical tones is capable of being analyzed into a sum of simple pendular vibrations, and to each such simple vibration corresponds a simple tone, sensible to the ear, and having a pitch determined by the periodic time of the corresponding motion of the air."

Fourier proved, in 1822, in a purely mathematical way, and with no idea of acoustical application, that any given regular periodic function, such as the most complex sound wave, can always be represented by a trigonometric series of sines and cosines, and for each case in one single way only. Each sine or cosine term in the series may be considered as representing a single simple component wave; then in Fourier's series, the successive terms have frequencies which are exact multiples of the first, but the amplitudes and phase differences are arbitrary and can always be found in every given case, by peculiar methods of calculation which Fourier has shown.

If the Fourier series corresponding to a given wave is determined, the wave is said to have been analyzed. The series may be written in the form of an equation for the mathematician, or it may be shown graphically for the physicist. (Charts and slides were shown illustrating the analysis of curves, and showing a harmonic analyzer, which is a kind of mechanical integrating device, and may be used with great convenience; it is only necessary to trace the curve with

a pointer attached to the recording device, and then to read from a series of dials the numerical data which determine the separate simple components of the complex wave. A harmonic synthesizer was also illustrated.)

In order that sound waves may be analyzed in accordance with the principles stated by Ohm and Fourier, it is necessary to have a record of the sound wave, that is, to have a curve which corresponds to the peculiar motions of a particle transmitting the sound. The most successful instruments that have been used for this purpose are the manometric flame, the telephone, the phonautograph, and the talking machine.

None of these methods seemed adequate for proposed investigations; and after several years' experimenting an apparatus has been developed which gives accurate records showing great detail. The instrument has been named the "phonodeik," meaning to show sound.

The sound to be recorded is concentrated by a horn upon a diaphragm; the motion of the diaphragm is communicated to a minute mirror. Light from the electric arc falls upon the mirror and is reflected to a moving photographic film in a special camera, producing the record of the sound waves. A magnification of about 2500 is commonly employed; the film moves at the rate of from five to fifty feet per second, and in some cases the spot of light has a velocity on the film of 1000 feet per second. The vibrator employed in making the photographs is very minute, the mirror being about 0.04 inch square, and the whole weighing about a thirty-second part of a grain. For purposes of demonstration a larger phonodeik has been made, which will exhibit the principal features of "living sound waves," so that a thousand people can see them. (A demonstration was made with the projection phonodeik, showing the sound waves from many sources and from the voice of the speaker during the concluding part of the lecture.)

The methods described are being used in an elaborate study of the nature of sounds from various sources, the results of which may be presented at some future time.

GENERAL NOTES

TWELFTH INTERNATIONAL CONGRESS OF NAVIGATION

The Twelfth International Congress of Navigation convened in Philadelphia, May 23, and was attended by considerably over 300 foreign delegates. A committee of our Society consisting of Charles Whiting Baker, Chairman, W. M. McFarland, H. deB. Parsons, George B. Massey, Stevenson Taylor, John W. Lieb, Jr., and Jesse M. Smith, augmented by T. C. Martin, E. E. Olcott, E. L. Corthell, met each delegate and welcomed him as he arrived in America. A special invitation was personally addressed to each and handed to him on the steamer, inviting him to make his headquarters at the Society's house and to use it to its fullest extent while in America. The official delegate to the congress was Wm. T. Donnelly.

The congress was opened by the President of the United States and by state and municipal representatives, and continued four days. The banquet on the last day was probably attended by the greatest number of engineers of any banquet held in the United States. At the conclusion of the meetings in Philadelphia professional visits were arranged as follows: one section went to Boston to view the Cape Cod Canal, and other sections went to Pittsburgh, to Washington and to New York. In New York the visitors were officially received by the City of New York and shown, under the guidance of Calvin Tomkins, commissioner of docks, the harbor and dock facilities. There was a reception at the rooms of the American Society of Civil Engineers and visits to the tunnels now under construction. Then followed a daylight trip up the Hudson to Albany where the engineers who had gone to Boston were joined and the whole party continued on a trip through the Great Lakes.

1912 FLANGE STANDARD

The 1912 Standard for Extra Heavy Flanges and Flanged Fittings, having reference mainly to sizes above 8 in. in diameter and ordered printed by the Council in the February Journal, was the result of

labors covering a period of considerably over a year by the committee consisting of Messrs. H. G. Stott, Chairman, A. C. Ashton, W. Schwanhausser, J. P. Sparrow and W. M. McFarland, acting in an advisory capacity to the National Association of Master Steam and Hot Water Fitters. This standard has been adopted by the Bureau of Standards and several of the other departments of the United States, and pipes and fittings made according to it may be secured from many firms, notwithstanding it has been in effect only since May 1.

Pipes and fittings made according to the 1912 standard are considerably heavier and stronger than those made according to the manufacturers' alternative standard or the standard adopted in 1904 by the Engineering Standards Committee of Great Britain, or the one adopted in 1900 by the Verein deutscher Ingenieure. In the report last year of the Alsace Association of Owners of Steam Machinery Plants is the statement that there have been a great many accidents in joints of pipes and valves made according to the last standard which had resulted in fatal consequences and that there was general dissatisfaction, all of which confirms the judgment of the Society's committee in increasing the strength of flanges where the initial mechanical strains of construction are often several times that due to the steam pressure.

In general the 1912 standard is intended for plants where no sum is considered too great which will ensure safety and continuity of service.

SUB-COMMITTEES OF THE COMMITTEE ON MEETINGS

Six additional sub-committees of the Committee on Meetings have been appointed as follows: Iron and Steel, Air Machinery, Railroad Equipment, Industrial Building, Hoisting and Conveying, Fire Protection. It is expected that papers and reports in the field of engineering covered by these committees will be presented during the coming year. Information will be of service and suggestions will be gratefully received from members having original material to offer in any of the lines of activity coming within the scope of these committees.

Attention has already been called to the fact that it is desired to have papers for the Annual Meeting on hand by September 1.

LOCAL MEETINGS

At the convention in Cleveland representatives from six cities met in conference and recommended the form of meetings which the Society should conduct in the several cities. This form was later adopted by the Council.

The substance of the method adopted is that local meetings be considered as sectional meetings with the local committee in responsible charge, and that the By-Laws and Rules of the Society now in vogue for professional meetings be applicable to the geographical sections.

A close relation between the Society's activities and activities of the several centers is maintained by the interchange of papers and contributions from the Society's funds, for the professional features of the local meetings.

Additional local obligatory fees, as such, are not favored either by the centers or by the Council, all members of the Society being by right entitled to attend all meetings wherever held. This, however, does not make it impossible for voluntary contributions to be made for activities, professional or social, which may be conducted by the local committees.

Another feature of the recommendation from the conference emphasized by the Council is that sections should build up and strengthen local engineering interests and societies in a broad and general way, with the assistance and coöperation pledged in advance by the national Society.

The Council has been greatly interested for years in the holding of meetings in the several cities as best promoting the general interest of the members, but has refrained from formulating rules till experience has been obtained to enable a satisfactory code to be designed.

INVITATION TO MEET IN GERMANY, JUNE 23-25, 1913

The Society is just in receipt of the following cable:

American Society of Mechanical Engineers,
29 West 39th Street.

The Verein deutscher Ingenieure has today unanimously resolved to invite The American Society of Mechanical Engineers to its next Annual Meeting in Leipzig.

Oskar Von Miller, *President.*

Preliminary announcement is thus made of the invitation, which has been accepted by the Council to a joint meeting of this Society with the Verein deutscher Ingenieure in Leipzig in June next year.

A committee of arrangements will shortly be appointed and the Society can expect an extraordinary opportunity to hold a meeting with the national society of Germany and make an official tour of the industrial centers, concluding with a meeting in Munich and a visit to the German museum of which Dr. Von Miller is president.

AN ANALYSIS OF ACCIDENTS IN A MACHINE TOOL WORKS

By Luther D. Burlingame

ABSTRACT OF PAPER

The paper deals with an analysis of accidents in a machine tool works showing what proportion of accidents are due to each of a number of different causes; also an analysis as to which departments of the works have the greatest number of accidents and further as to the degree of disability resulting from the accidents. The purpose of the paper is to learn from past experience how to reduce accidents in the future.

AN ANALYSIS OF ACCIDENTS IN A MACHINE TOOL WORKS

By Luther D. Burlingame, Providence, R. I.

Member of the Society

In making a study of safety methods and safety devices, an analysis of the accidents that have occurred in one of our large machine shops may be of service for still further protecting the workmen when engaged in their various lines of employment.

2 A careful record of all accidents in the works of the Brown & Sharpe Manufacturing Company has been kept during the last seven years and a study made of them for the purpose of ascertaining where danger is greatest, what accidents are preventable and how best to avoid them. It may be said that in this factory extra care has been taken for many years to guard against accident and the management has never hesitated to spend money for that purpose when convinced that it would bring about safer conditions. During the last year an additional effort has been made to profit by past experience both at our own works and by the experience of others and still further to tune up the safety equipment and spirit of the organization in order that accidents might be reduced to a minimum.

3 When this additional work was undertaken, about a year ago, an analysis of all accidents which occurred during the previous six years was made along three lines: (*a*) the percentage of accidents under each of 18 headings from different causes; (*b*) the percentage by departments of the shop, divided into more than 30 groups; (*c*) the seriousness of the injury and the resulting length of disability from work. Following this, a similar record is being kept each year showing (*d*) what kinds of accidents are increasing and what kinds are being decreased by the further safety methods being adopted,

Presented before the April 1912 Meeting of the Providence Association of Mechanical Engineers (Affiliated with The American Society of Mechanical Engineers).

also which departments are reducing their accidents and which are growing worse.

4 The different kinds of accidents were classified as follows, and the percentages given are for the six years preceding the date of the investigation, i. e., 1905 to 1910 inclusive:

	Total Accidents	Percentage
Caught in machinery	78	7
Caught or struck by belt	23	2
Set screw or other projection	29	2.6
Falling on or striking workman	226	20.1
Workman falling or strain lifting	75	6.7
Machinery starting unexpectedly	8	0.7
Chain or rope slipping or breaking	10	1.0
Punch press, rolls, or shears	20	2
Cutters and metal saws	94	8.5
Handling work or chips—eyes	126	11.2
Woodworking machinery	47	4.2
Burns, including electricity	79	7.0
Cuts with sharp instruments	20	2
Jams and hammer blows	71	6.3
Caught in tool and work (not cutters)	176	15.7
Elevator	4	0.5
Fooling	13	1.2
Litter or dark places	15	1.3

5 These accidents naturally divide into two groups: (1) those caused by machinery either (*a*) by being caught in the gearing, belting or other parts of the machinery, or (*b*) by being injured by the cutter or other tool or caught between the tool and the work; (2) those caused by falling, jams, burns, cuts, etc. The first group includes, 42.7 per cent of the accidents occurring during the six years, divided as follows: group (*a*) 12.3 per cent; group (*b*) 30.4 per cent. This leaves 57.3 per cent as the proportion of accidents occurring under the second group.

6 From the above analysis it will be seen that if complete guards could be provided so that every accident due to being caught in gearing, on set screws, or anywhere in the mechanism of machinery would be avoided, it could at most only reduce the accidents 12.3 per cent. Several recent occurrences show the unexpected accidents which result from this cause. A workman, hearing a rattling in the knee of a milling machine he was running, reached his hand underneath to see if the cause were due to a collar which he thought might have become loose, and stuck his finger into the running gearing.

7 Another case was that of a workman who reached for a can

of oil which he had left on a ledge of the machine. In lifting it up he caught a finger in the pump gears back of the guard. Both of these accidents occurred on machines considered sufficiently guarded, and to experienced workmen, indicate that to have complete safety it may be necessary to enclose all gearing entirely, whether or not it is exposed.

8 A way of preventing accidents by being caught by set screws or other projections, also coming under this division, is to insist on the wearing of short-sleeved jumpers, to avoid loose clothing, hanging neckties, etc. One of the apprentices at the Brown & Sharpe Manufacturing Company's works was injured recently by having the pocket of his jumper catch on the set screw of the revolving dog while he was filing. All of the boys running machines at this plant are obliged to wear short-sleeved jumpers and the men are advised to. Seventeen of the accidents reported were due to being caught by the sleeve of the jumpers.

9 The company is now experimenting with various forms of safety dogs, none with the projecting set screws having been added to the equipment during the last year. The plan of changing the regular dogs for headless screws adjusted with a socket wrench is also being tried experimentally.

10 The accidents in group (*b*) are more frequent and more difficult to guard against. It is practically impossible in many cases to do guarding at the point of cutting, and if guarding is attempted it may introduce dangers greater than those sought to be avoided. It is, however, possible to insist that the fingers shall never be used to wipe off chips, etc., from a running cutter. Out of the 94 accidents from cutters reported, 30 were caused by being caught when wiping off chips with the fingers.

11 In the use of punch presses 20 accidents had occurred in the period investigated, so this was one of the first matters to be considered. The means adopted for guarding against these accidents were novel, as far as the author is aware, and have proved fully successful both in avoiding accidents and in preventing an appreciable increase in cost of doing the work. A rule was made that the fingers and hands must never be put between the punch and die. Tweezers and pliers were furnished for handling the work, the points being shaped in some cases to suit particular jobs. The only accidents since have been to the points of the tweezers and pliers. Chutes have also been used to slide the work into position, a

stick being used to remove it after the operation. For some work which it was thought could not be handled by the above means, a swinging fixture was designed so that the work can be put in place away from under the punch and then swung into position for the operation.

12 The 47 accidents from woodworking machinery were largely cuts from circular saws, but included eight where the block of wood was thrown back when slitting, two of the cases being fatal, the only fatal accidents in the works during this period. The men are now required to wear a heavily padded apron when using a slitting saw, and this has, it is believed, saved the lives of several workmen. The use of a "spreader" when properly installed helps to prevent such accidents by keeping the cut from closing in back of the saw.

13 Another prolific source of accidents which, while not serious perhaps, are painful, is in being cut by revolving grinding wheels, especially when doing internal grinding and trying the plug in the hole without running the wheel back a sufficient distance. Twenty-eight of the accidents were from this cause. A shield has been designed which automatically swings up in front of the wheel so as to protect the hand if the plug should slip.

14 Under the second group, falling, jams, burns, cuts, etc., a large proportion of the accidents are entirely within the control of the workman, either the one hurt or a fellow workman, and the remedy is largely to be found by employing careful methods. In this, however, the foreman can exercise a large influence for safety. Some specific remedies can also be applied. It was found that 37 cases of burned feet in the foundry had resulted from wearing laced or low shoes. A rule was made that Congress or other high shoes without lacing should be worn, and a supply of such shoes is kept and sold to the foundrymen at about cost. This has nearly remedied the trouble. There remains, however, the liability of the iron spattering into the tops of the shoes and burning the legs when the pants are ragged. A study is being made of the possibility of using pants made of non-burnable material.

15 About one-fourth of all the accidents are caused by weights falling on the workman and jamming or cutting either the hands or the feet, and from the workman himself slipping and falling. The remedy here is to use care that safe methods are employed and that men do not take chances. Classified with these are 13 accidents traceable to "fooling," some occurring outside of working hours.

16 In considering the classification by departments and kinds of

work, it was found that, for the period of six years, the average number of accidents was greatest in the following departments, the percentage of employees injured each year being as follows:

(*a*) *Grinding department*, 13.8 per cent, being caused largely by cuts from grinding wheels. This has been much reduced during the past year, so that this department now ranks eighth instead of first in order of accidents.

(*b*) *Laborers*, 10.6 per cent, largely from injury by falling objects, jams, strains in lifting and the workman falling.

(*c*) *Carpenters*, 10 per cent, a large proportion of the injuries being due to woodworking machinery.

(*d*) *Foundry*, 9.5 per cent, due mainly to burns, also to falls and falling objects.

17 Then follow the various machine departments from 7.6 per cent down to 2.2 per cent, and ending with the inspection department, the offices and the drafting department with the percentage coming down to 0. Only four elevator accidents, and these slight, occurred during the six years, a very good showing with more than a dozen elevators in constant operation.

18 In the classification by seriousness of injury and length of disability of 1124 accidents occurring during the period of six years covered, 382 resulted in no disability, that is, no absence from work. In 457 cases there was less than one week's absence from work. Of the remaining 285 cases, 132 resulted in between one and two weeks' absence; 74 in two to four weeks' absence; 51 in one to three months' absence; five in three to six months' absence; and five in over six months' absence; in addition, eight were hurt so as to cause the loss of an eye, a foot or permanent injury, two dying from the effects of their injuries. Ten men left, and no record was kept of the duration of their disability. These statistics form a good basis for future investigations looking towards a still further accident reduction.

19 In 1911, with an average of 4050 employees, there were 243 accidents, or about 6 per cent of the workmen were hurt sufficiently to report; this on a basis of reporting slight accidents as well as those of a more serious character. Some of the added measures for safety had been in operation during part of the year, so that the gain from $6\frac{1}{2}$ per cent, the record of the previous year, to 6 per cent for 1911, indicated a gain due to such further safeguarding. This gain was also shown in the reduced number of serious accidents included in last year's list. There were no fatal accidents; no loss of

eye or limb, and more than 70 per cent of the reported accidents resulted either in no disability or in less than one week's loss of time.

20 In some few departments, where accidents increased during the past year, special steps are being taken to ascertain the cause and to avoid a repetition. Each accident is studied to learn the lesson it teaches as to further methods of safety. It is hoped by such means to reduce the accident list to a minimum for the benefit of both workmen and employers.

THE MORE FUNDAMENTAL PRINCIPLES OF PATENT LAW

By Edwin J. Prindle

ABSTRACT OF PAPER

The purpose of this paper is to present to the engineer and manufacturer an explanation of the more fundamental principles of patent law, in plain English, without the use of legal phraseology. The paper also gives an example of a typical commercial development, undertaken for the purpose of establishing a patent monopoly, the development serving both to illustrate many phases of the procedure of conducting such a development and as a concrete example for use in explaining the principles of the patent law.

THE MORE FUNDAMENTAL PRINCIPLES OF PATENT LAW

THEIR EXPOSITION IN A POPULAR FORM IN CONNECTION WITH A TYPICAL INDUSTRIAL DEVELOPMENT, FOR THE PURPOSE OF ESTABLISHING A PATENT MONOPOLY

BY EDWIN J. PRINDLE, NEW YORK

Member of the Society

It is the purpose of this paper to give to the engineer and manufacturer a sufficient understanding of the more fundamental principles of the patent law, including the nature of a patent, the protection it may afford, how it may affect his relations with his competitors, and the principles applied by the courts in enforcing patents; so, that knowing in a general way what may be accomplished by patents, he will be "put on his inquiry" and neither let opportunities to avail himself of patents escape, nor blindly run into difficulties with the patents of others. It is not the purpose of the paper to make him his own lawyer, but rather to enable him to tell when counsel is needed and to coöperate intelligently with his counsel.

2 To make the exposition of these principles more interesting and, at the same time, to illustrate a campaign of patent engineering to establish a patent monopoly, I shall explain these principles in connection with a typical industrial development. This development is an actual experience; I have chosen it for the purpose of illustration, because it is one of the most extensive and complete efforts to develop a new commercial situation, and protect that situation by patents with which I am familiar, and therefore, I think, affords many suggestions which would be of use in attempting similar developments in other fields.

THE OBJECT OF THE DEVELOPMENT

3 For the manufacture of shoes, a very large number of lasts are made each year, amounting to several million pairs. This

Presented at the New York meeting (May 1911) of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

business has been conducted by over sixty different establishments, there being no patents to prevent anyone from making the ordinary last, which comprises 75 per cent of all that were used. The object of the development has been to establish a patent situation which would enable the bulk, at least, of this large business to be monopolized. The ordinary last, shown in Fig. 1, consists of a single piece of wood from toe to heel, with a detachable instep block adapted to be removed after the shoe has been built around the last, so that the main portion of the last could itself be removed. This last has certain great disadvantages, among others that it cannot bend, as the foot bends in coming out of the shoe, and consequently, the shoe is somewhat strained in being taken off the last after having been built around it, and the shoe cannot be made exactly the shape of the foot, especially the curve at the back of the heel, because if this unbendable kind of a last were made the exact shape of the foot, the shoe could not be taken off the last. Previous to the development in question, lasts had been put on the market in which the old last was made in two pieces connected by a hinge at about the

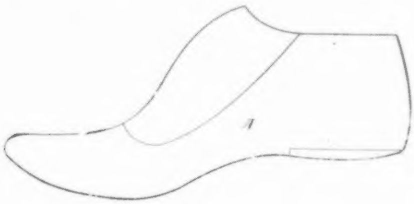


FIG. 1 OLD BLOCK LAST

instep, as shown in Fig. 2, so that the last could be bent, and, in effect shortened, like the foot in taking it out of the shoe. These lasts comprise the remaining 25 per cent of those sold.

4 The shape of the toe of a last, of course, conforms to the shape of the toe of the shoe, and a manufacturer, under the old system, had as many sets of lasts as there were different styles of toes. As the heel of the last is always the shape which the manufacturer conceives to be the shape of the average human heel, it does not change with the style of the last. Therefore, it was conceived in the new development that, if lasts could be made having the advantages of the hinged last of Fig. 2, but having the toe part readily detachable from the heel, it would be possible for a shoe manufacturer to have one set of heels large enough to keep all his machines busy, and to use those heels with toes of many different styles. This would

enable him simply to attach whatever style of toe he wanted to manufacture from to his standard heels and then, in filling the next order, to use these same heels with some other style of toe. If the detachment was made between the toe and the hinge, then there would need to be only one hinge for each heel, and not a hinge for each of the separate toes. As the number of heels would be much less than the number of toes, this would effect a great saving in the cost of hinges, and consequently of lasts, to the manufacturer. When the shoe manufacturer wanted to put out a new style of shoe, he would need only to order new toe parts, and would be able to use the old heels with their hinges. The toes would need but little metal attached to them, and, if a cheap and accurate method of making the toes could be devised, it will readily be seen that the toes could be sold at a much lower cost than an entire pair of hinged lasts, comprising both toes and heels, and yet be as good to the shoe manufacturer as an entire pair of old lasts, and permit a heavy profit to be made by the manufacturer of the lasts.

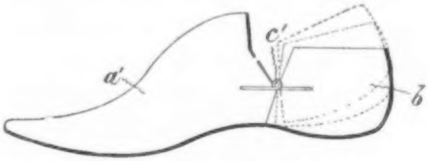


FIG. 2 OLD HINGED LAST

5 Therefore, the object of the development was to devise a last consisting of a toe and heel connected by a hinge, the toe being readily detachable from the hinge, and to devise machinery and methods of manufacture which would enable these parts to be cheaply and accurately manufactured, the accuracy being necessary so that any toe, when secured to any heel of the corresponding length and width of shoe, would with that heel make a complete last which would be accurate in its shape and measurements. It is necessary that the lasts be accurate in shape and measurement, because the parts of the shoe are made separately in large numbers, and, when they are assembled together upon the last, they must fit the last and each other so accurately as to make a well-made and well-fitting shoe of the desired shape and size. It is desirable to cut the parts of the shoe with as little waste as possible, because of the expense of the leather, and the greater the accuracy, the less need be the amount of waste.

NUMBER OF KINDS OF INVENTIONS WHICH CAN BE PATENTED

6 It was next considered how many kinds of patents this development is likely to form a basis for. The law provides for patenting four different classes of inventions: (*a*) arts, or, as they are usually known, methods, or processes; (*b*) machines; (*c*) manufactures; (*d*) compositions of matter.

These classes of inventions will be better understood as they are illustrated in applying them to our typical development. I may briefly define them, however, as follows:

a An art may be any process or series of steps or operations for accomplishing a physical or chemical result.

b A machine is any assemblage of mechanical elements having a law of action of its own.

c A manufacture is anything made by the hand of man that is not an art, machine or composition of matter. A knife having a stationary blade would be an article of manufacture. If, however, the blade were pivoted, it would be a machine, for it would then have a law of action of its own between its elements. The line of demarcation between manufactures and machines is not at all important, so long as it is clear that a proposed subject of a patent is one or the other of these classes of inventions, the object being to determine whether the invention is one that comes under the patent law. There are many inventions which are not patentable The department store is a very valuable invention commercially, but is not such a one as the patent law contemplates protecting.

d A composition of matter is any mixture or combination of chemical elements, whether solid, liquid or gaseous.

A combination of elements may be patentable even though all the elements are old, taken separately, or taken in any combination less than the whole number, so long as the elements of the new combination are sufficiently related as to constitute a unity in their co-action or ultimate result.

A new use of an old device or machine or process may be patentable, if the new use is so different from the old use as not to be obvious to an ordinary skilled workman in the art.

PATENTS POSSIBLE IN THE NEW DEVELOPMENT

7 Theoretically, in our new development, there were seven different classes of patents which could be obtained.

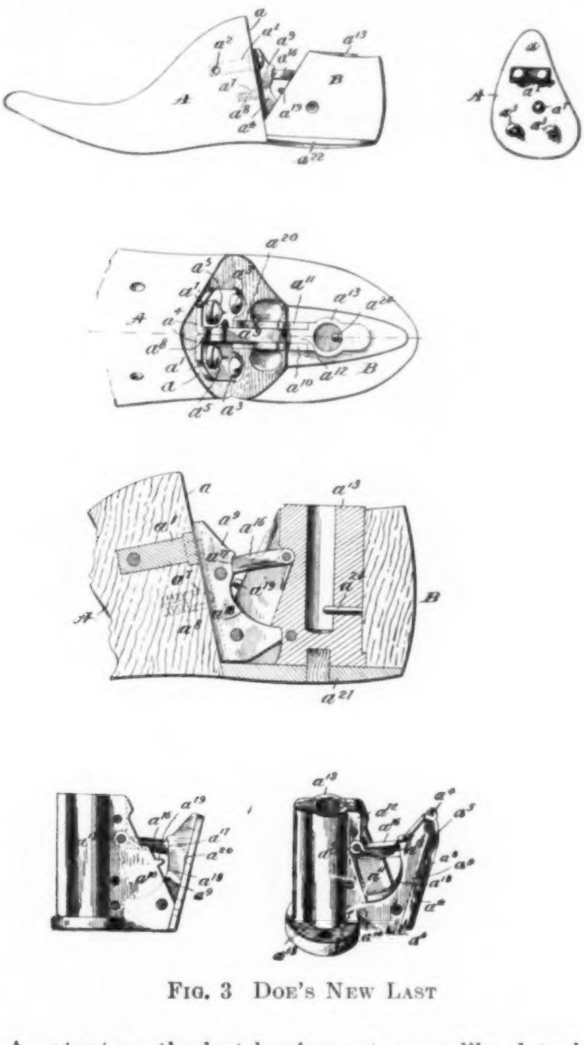


Fig. 3 Doe's New Last

a A patent on the last having a toe readily detachable from the hinge.

b A patent or patents on a method or process, or procedure, or series or succession of steps or operations for so making

the lasts that the toe and heel parts would be interchangeable, and that when any two of them were fitted together they would make a last accurately conforming in shape and dimensions to the model required.

c A patent or patents on machinery for practising such a method or process.

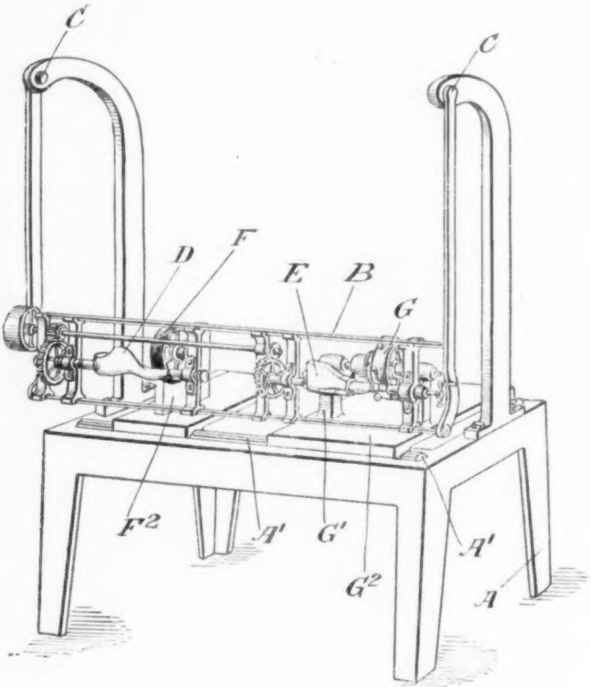


FIG. 4 OLD LAST LATHE

d A patent on a blank from which the interchangeable toes and heels were to be made by such method.

e A patent on a new composition of matter from which the lasts could be made.

f A patent on an advantageous method or procedure of making shoes which the new last made possible, and which will be later explained.

g A patent on a combination of the removable toe with an expansible leg in a shoe dressing and ironing machine.

8 The first task to which the inventor of the new development (John Doe, as we shall call him for the purpose of this paper) set

himself was, therefore, to invent a last consisting of a toe and heel connected by a hinge, the connection between the toe and the hinge being of such a nature as to be readily detachable when desired, and yet the whole structure be rigid and strong when the last is in condition for use. This last is shown in Fig. 3.

9 The last, briefly, consists of a toe A and heel B connected by a hinge. The toe has two studs a^1 and two screws a^3, projecting from its rear face, for the purpose of detachable connection with the front plate a^4 of the hinge, the said plate having upper key-hole slots a^5 which engage the studs a^1 and lower key-hole notches a^6 which engage the screws a^3. A small spring bolt a^7 is also mounted in the rear face of the toe to engage a hole a^8 in the plate and lock the plate on the last when it is home on the studs. A plate a^9 extends rearwardly from the plate a^4 and is pivoted between plates a^{10} and a^{11} fastened to a projection a^{12} of a drop forging a^{13} in the heel B. A shoulder a^{14} on the rearwardly projecting plate a^9 engages a shoulder a^{15} on the drop forging, when the last is in extended position, to prevent the hinge from opening too far. A locking piece a^{16} is pivoted between plates a^{10} and a^{11}, and bears against a shoulder on the plate a^9 to keep the hinge extended. A spring normally tends to throw the locking piece into locking position. When the last is to be collapsed, the locking piece is depressed and held down until the collapsing movement causes it to be caught by a cam surface a^{18} on the plate a^{19}, after which the unlocking device can be withdrawn, and the cam surface will complete the depressing of the locking piece by the collapsing movement. A projection a^{19} on the plate a^{11} is caused by the collapsing movement, to push back the spring bolt a^7, so that the last is not only collapsed, but the hinge is unlocked from the toe, and the toe can be removed. The forging a^{13} is provided with a flange at its lower end to which a metal heel plate a^{27} is fastened, so that the heavy operations in the early part of the making of the shoe can be borne by the metal parts of the heel, the wood being insufficient to stand the strains.

10 Having invented the last, it was necessary to be able to make it, as before stated, so that the toes and heels of the same length and width should be absolute duplicates, and interchangeable. Commercially, it was necessary to be able to make these toes so that they would accurately and interchangeably fit heels in a perhaps distant shoe factory, made, perhaps, several years before.

11 The machinery and method of manufacture of hinged lasts which were in use at the time of the new development were incapable of making interchangeable last parts. Such old procedure was to make a model last which met the approval of the shoe manufacturer and then to duplicate that last in a lathe, variously known as the Blanchard, or gun-stock, or last-turning lathe. Such a lathe is illustrated in Fig. 4. The lathe consists essentially of a stationary frame *A* having a "swing frame" *B* pivoted thereto at *C*. The swing frame has headstock spindles and dead centers which are adapted to support a model last *D* and the block *E*, from which the new last is to be formed, and to rotate them on axes in

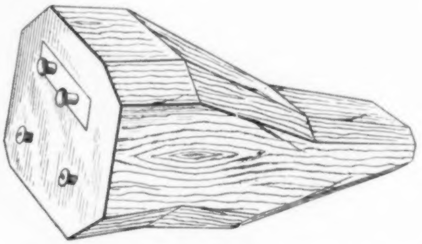


FIG. 5 DOE'S BLANK FOR MAKING LAST TOES

line with each other. On the frame *A* are journaled a model wheel or tracer *E* and a cutter head *G* of exactly the same diameter as the model wheel and describing a similar surface of revolution. The model wheel pivot is mounted on a slide (not shown) adapted to move forward and back across the machine on an upright F^2 that is carried by a slide mounted on a guide A^1 extending lengthwise of the main frame. The cutter head is mounted on a journal having bearing in uprights G^1 carried by a slide G^2 which also travels on the guide A^1.

12 In the operation of the lathe, a spring or the weight of the swing frame normally draws the swing frame towards the main frame until the model rests against the model wheel or tracer. As the model revolves, it swings the swing frame back and forth, so that the cutter head cuts out of the block, or blank, a new last of the same shape as the old one. The carriages of the model wheel and cutter head are caused slowly to travel lengthwise of the main frame so that all parts of the model surface are presented to the model wheel and the corresponding parts of the new last are shaped.

13 The action of the lathe is as though the tracer or model wheel moves, while the swing frame remains still the model revolving on its axis, however, and the cutter controlled by and moving in unison with the tracer, duplicates the shape of the model in the block. The model is a cam, controlling the cutter through the tracer, or model wheel.

14 By means of certain grading mechanism (not shown), the model wheel carriage F^1 may be moved in and out, proportionately, as the swing frame moves, so that a wider or narrower last will be formed than the model. By means of certain other mechanism (not shown), the proportionate travel of the main carriages F^3 and G^2 may be varied so that a longer or a shorter last will be formed. It will be seen that the new last is formed in a single piece from toe to heel, and in practice a "nub," or unfinished portion, is left at the toe and heel where the chuck and dead-center support the wood.

15 The old procedure of making hinged lasts was to make duplicates of the model of a single piece of wood from toe to heel, as though an old solid last were going to be made, and then to saw up this one-piece last into a toe and a heel and fasten these parts to a hinge. Of course, the toe and heel which were sawed apart would always fit together, because they were originally parts of the same last. As, however, a last has no straight lines and no corners to measure from or gage by, and is wholly composed of irregular curved surfaces and lines, it is impracticable, as a commercial proposition, to saw up whole lasts so that the toes and heel will be interchangeable.

16 Our inventor, Doe, solved the problem in the following manner. He conceived the idea of providing the model headstock of the old spindle last-turning lathe with a face plate against which the rear face of the model toe part could be held, and providing the headstock spindle for holding the rough block out of which the new part was to be made, with a face plate parallel to the model face plate. He then made a blank, as shown in Fig. 5, which consisted of a block of wood having a dressed end, which is to form a rear face of the new toe part, and having studs and screws fastened in it, precisely like the model toe. In order to hold the model toe and the blank against their face plates, Doe provided chucks which are shown in Fig. 6. These chucks consist of a spindle h having a face plate h^{20} and having cylindrical plugs (see lower right-hand corner Fig. 6) journaled in the head of the chuck. The plugs have undercut recesses h^8 which are adapted to receive the heads of the studs and screws on the toes. The plugs have collars on their shanks which

engage notches in the corners of a plate h^{12}, the latter having a shank h^{13} pivoted to a screw-rod h^{14} which can be moved back and forth by a hand wheel h^{15}. In the operation of the chucks, the plugs being in their forward position and their undercut slots exposed, the studs and screws on the toe or blank are engaged with the undercut slots,

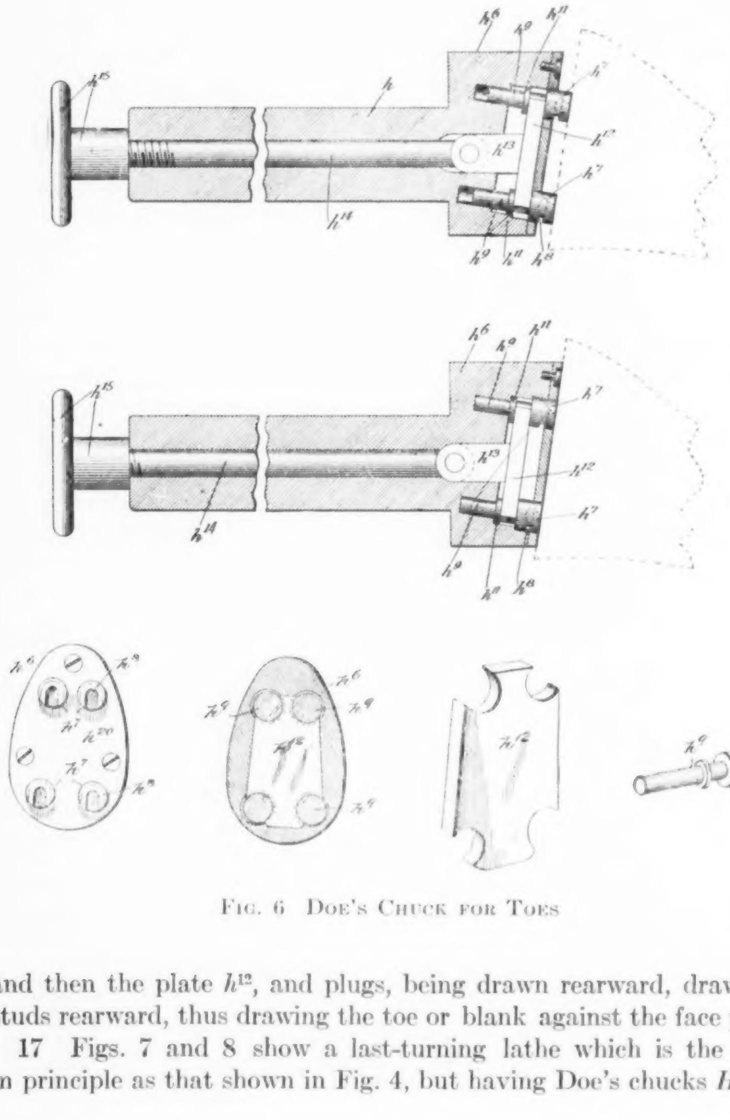


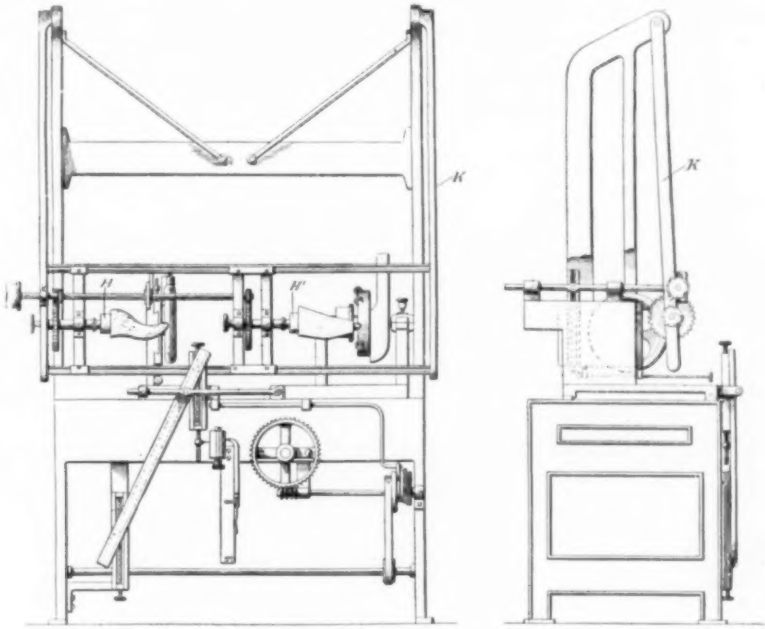
FIG. 6 DOE'S CHUCK FOR TOES

and then the plate h^{12}, and plugs, being drawn rearward, draw the studs rearward, thus drawing the toe or blank against the face plate.

17 Figs. 7 and 8 show a last-turning lathe which is the same in principle as that shown in Fig. 4, but having Doe's chucks *H* and

H^1 mounted in the headstocks of the swing frame K. The swing frame is like that of the lathe of Fig. 4.

18 In Doe's method, the rear faces of the model toe and the toe being formed are always parallel, and, as the foot-shaped contour is formed on the blank parallel to the foot-shaped contour on the model, the foot-shaped contours of the model toe and the new toe bear the same relation to their rear surfaces, and these toes are,



FIGS. 7 AND 8 LATHE HAVING DOE'S CHUCK APPLIED AND PRACTISING DOE'S METHOD OF TURNING LAST TOES

therefore interchangeable. Incidentally, Doe also finishes the entire tip of the new toe by the machine, and saves the cost of doing it by hand-labor, as required by the old process, a cost nearly as great as that of turning the entire remainder of the last. Figs. 9 and 9*a* are photographs of Doe's lathe practising his method of turning last parts.

19 Doe's method, then, consisted in forming a finished or standard surface on the rear end of his blank, corresponding to the rear surface of the model toe, and then, so mounting the toe and blank in the lathe that these rear surfaces shall always be parallel to each other,

and forming a foot-shaped contour on the blank by a cutter guided by the foot-shaped contour on the model toe. This method or procedure was patentable under the statutory head of "arts," and we shall see later exactly how it was protected.

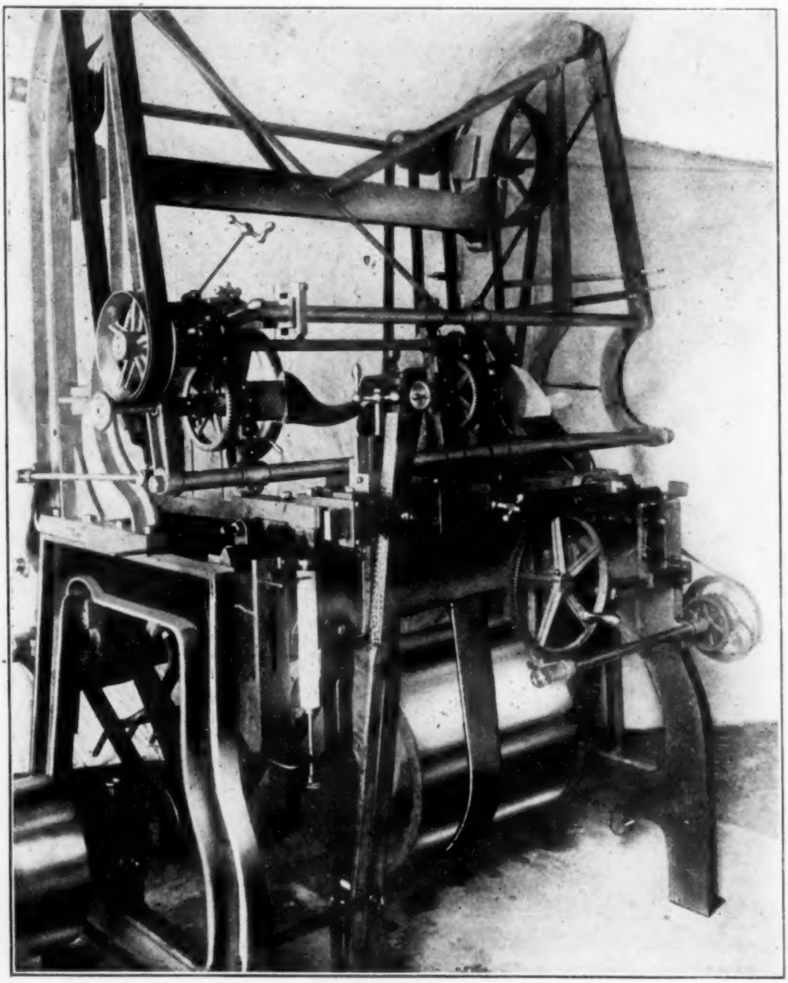


FIG. 9 DOE'S ACTUAL LATHE

20 It was necessary for Doe to make certain improvements in the grading mechanism of the lathe, whereby the new toe could be made longer or shorter, or wider or narrower, than the model

toe, because with the grading mechanism of the old lathe, he could not foretell with exactness the length of the new toe which would be produced, as he must be able to do if it were going to bear only its proportionate part of the length of the last, to make a last of

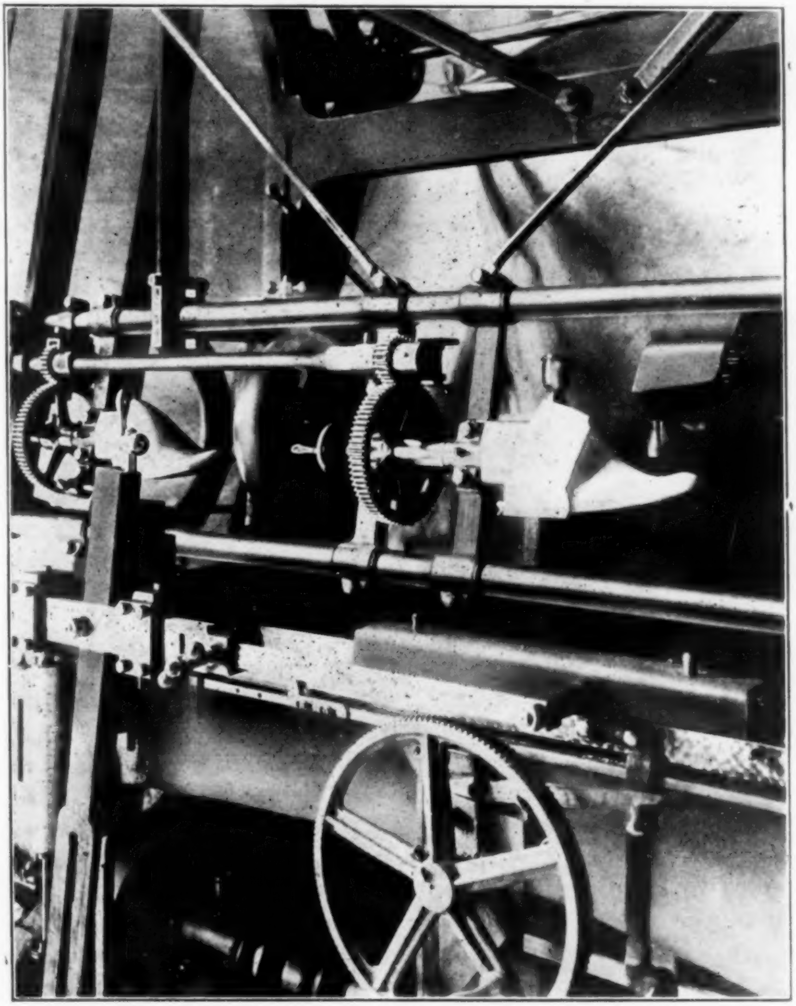


Fig. 9a Doe's Lathe Showing the Practising of His Method

exactly the right length when placed on a heel. These improvements in the lathe were patentable under the statutory head of "machines."

21 The blank shown in Fig. 5, in which the toe was to be made

was patented under the statutory head of articles of manufacture. If Doe had been able to discover a composition of matter which is as strong as the rock maple, from which lasts are universally made, but which does not have the disadvantage of shrinking and swelling with the variations of humidity, he could have patented this composition under the statutory head of compositions of matter.

22 In the manufacture of shoes, the parts of a shoe are built around the last, and the operations which cause severe strain on the last, such as the operations of drawing the upper around the last, or "lasting," rolling the sole to shape it to the last or "sole leveling," and driving the heel on to the last (the heel being made separately and fastened on all at one operation) or "heeling," all occur during

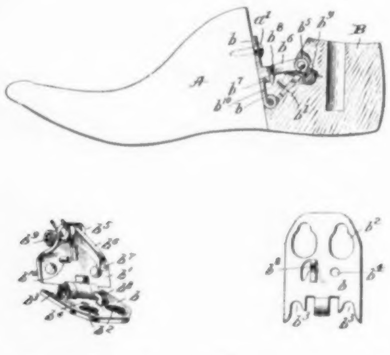


FIG. 10 DOE'S LIGHT HEEL FOR HIS LAST

the first few hours of making the shoe, while subsequent operations and the drying of the shoe on the last (which is done with every good shoe) take much longer. As the shoe is built around the last, it is desirable that it should dry on the original toe upon which it is built, since it is impossible to take that toe out and put another toe in and have the new toe fit perfectly into the shoe. Doe, therefore, wanted to leave his toe in the shoe throughout its manufacture, but conceived that, since his heel was heavy and somewhat expensive, to make it strong, if he could take his heavy heel out of the last when the heavy operations were over and put in a lighter, cheaper heel, this would enable the expensive, heavy heel to go back and begin at once the manufacture of a new shoe, thus reducing the number of heavy heels which a manufacturer would need and also saving the workmen the effort of handling the shoes with the heavy heels in them

23 Doe, therefore, invented a light heel shown in Fig. 10. The hinge consisted of a front plate b adapted to engage the studs and screws on the toe, a rear plate b^1 hinged to the front plate and adapted to be screwed to the wooden heel B. A locking piece b^6 is pivoted to the rear hinge plate and is adapted to engage a hook b^8 on the front hinge plate when the last is extended and to be flattened down out of the way when the last is collapsed. The collapsing of the last shortens it enough to allow room in the shoe for engagement or disengagement of either hinge with the studs and screws on the toe.

24 Doe was, therefore, able to collapse the heavy heel and disengage it from the toe and withdraw it from the shoe, and to insert the light heel with its hinge collapsed, engage the hinge with the studs and screws of the toe, and swing the light heel into normal, extended position without disturbing the toe in the shoe.

25 Doe patented both the combination of the single toe with the light and heavy heels, and the method of making shoes which consists in starting the manufacture with a toe and a heavy heel, and then, after the heavy operations on the shoe are over, removing the heavy heel and substituting the light heel, and continuing the manufacture of the shoe.

26 In the manufacture of shoes, as practised before Doe's invention, finer grades of shoes were placed upon a form consisting of a foot and a leg on which they were dressed and ironed, as the last step before going into the boxes for shipment. As Doe had made his toe removable from the hinge, he invented a leg to which it could be attached, and that, without disturbing the position of the toe in the shoe, so that he not only saved the expense of the special toes for this ironing operation, but the labor of replacing the last by the special toe, and he thus made it possible to conduct the manufacture of the shoe, from beginning to end, upon a single toe around which the shoe was built and which was never disturbed, the manufacture starting with a heavy heel which was later replaced by the lighter heel, and that later replaced by the expansible leg of the machine upon which the shoe was ironed. The combination of the heel and leg with a toe adapted to be attached to either of them, was patentable.

27 As in all developments, the last and machinery went through more or less evolution, usually more, and a system and special machines were invented to prepare both the toe and heel blanks to fit the hinges so that they might be given their foot-shaped contour in accordance with the method which Doe had invented. It is unneces-

sary to describe any of these evolutions and machines, as what has been described is sufficient for the purpose of an illustration, both of the method of producing such a commercial development and of the types of inventions which can be protected.

THE NATURE OF A PATENT

28 Having now sketched the development, I wish to explain how it was protected by patents, and for the purpose of doing so, shall endeavor first to explain the nature of a patent.

29 The law provides for the granting of patents only to actual inventors and requires, as the price of the patent, that the inventor shall describe his invention so fully that anyone skilled in the art

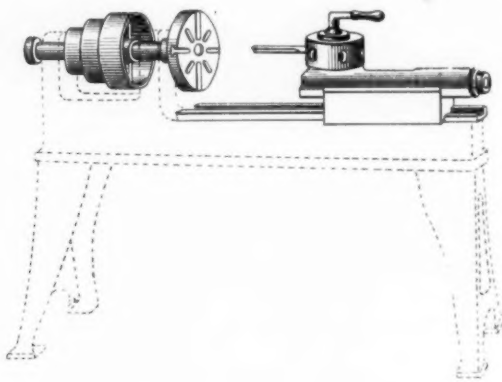


Fig. 11 Turret Lathe

can make and use the invention after the patent has expired, the law giving the inventor, in compensation, an absolute right for a period of 17 years to forbid all others from making, using or selling the invention. As every invention is an evolution from ideas which preceded the inventor's conception, occasionally being the last step of a series of improvements extending through centuries, some, and often much, of the structure or procedure which the inventor discloses is not his own invention, but is the foundation upon which he has built or from which he evolved his invention.

30 In order that the public may know what it is free to do, and in order that the courts may know when an invention has been used by others, the law requires the inventor to point out the part,

improvement or combination, which the inventor regards as his invention or discovery. The necessity for this has developed the practice of requiring the inventor to make one or more series of short, terse statements or descriptions of what he regards as his invention, at the close of his detailed description, these statements being technically known as claims.

THE NATURE OF A CLAIM

31 A claim is the measure of the monopoly granted by the patent, and it is vital, therefore, that it be skilfully drawn; for most inventions are an "idea of means" embodied in a particular form, and many clever mechanics could get the same result by

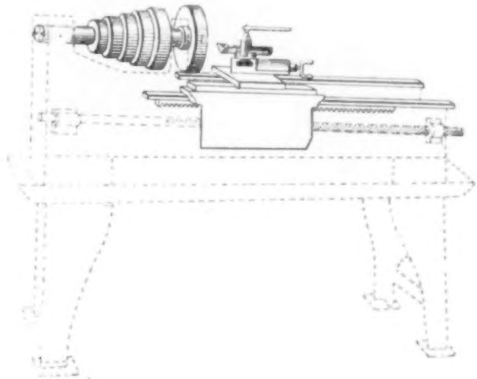


FIG. 12 LATHE WITHOUT TURRET

changing the form of embodiment without changing the principle of the invention, or the idea of means. It is therefore very desirable that the monopoly granted by the claims shall be broad or comprehensive enough to include all possible changes of embodiment which do not involve a change in the idea of means.

32 For the purpose of illustrating the nature of a claim, I shall deviate temporarily from our example of a commercial development, using certain machine tools for the purpose of illustration, as they are a more convenient form of illustration for this particular point.

33 We will suppose our inventor, John Doe, to have invented the first turret lathe. Doe might have claimed his invention as follows:

I claim a machine tool consisting of the combination of a bed having ways, a headstock on said bed, a spindle journaled in said headstock, a chuck on

said spindle, a slide mounted on said ways, a turret revolubly mounted on said slide, a series of tools mounted in said turret, a rack on said slide, a pinion journaled on said bed and engaging said rack, and a hand wheel for turning said pinion, whereby a piece of work may be secured in and revolved by said chuck, whereby said turret and tools may be advanced against and retracted from the work, and whereby said turret may be turned to bring its various tools into cutting position.

34 Suppose, now, that Doe's turret lathe was the first machine ever invented in which the work was revolved, and a tool mechanically held on a slide was moved against the work. Suppose that

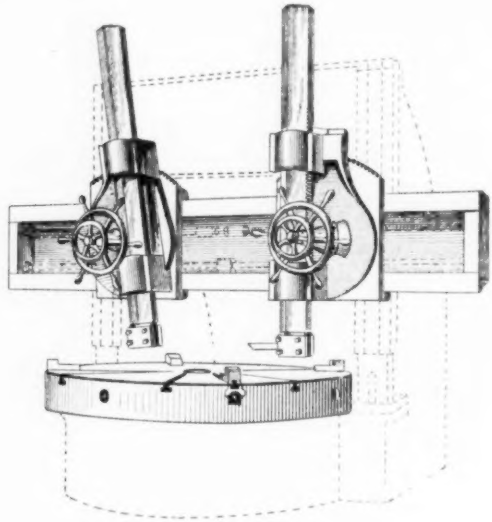


FIG. 13 BORING MILL

after Doe's invention, the lathe without a turret, the boring mill, the pipe-threading and cutting machine and the locomotive tire-boring machine were invented. It is apparent that, at least in a general way, these tools work on the same principle as Doe's turret lathe. In Figs. 11–15 I have illustrated the five types of machines to which I have referred, and have shown in full lines in each machine the revolving work holder (such as the headspindle of the lathes, the table of the boring machine, etc.), the tool carriage, and the guides on which the tool carriage is mounted, these being the essential features of Doe's invention and being features which are found in every one of the five types of machines. The features, other than

the essential features, which differ in the various machines are illustrated in phantom lines. It will be seen that although all of the four machines following Doe's invention use the basic idea embodied in his machine, none of these machines answers to the description of his invention which he made in his claim. For instance, none of them has the turret, and most of them lack other elements of his claim. The courts will not permit an inventor to enjoin the use of a machine which omits an element of his claim. If the inventor describes his invention in a claim consisting of six elements, and some one else finds that he can accomplish the same results by

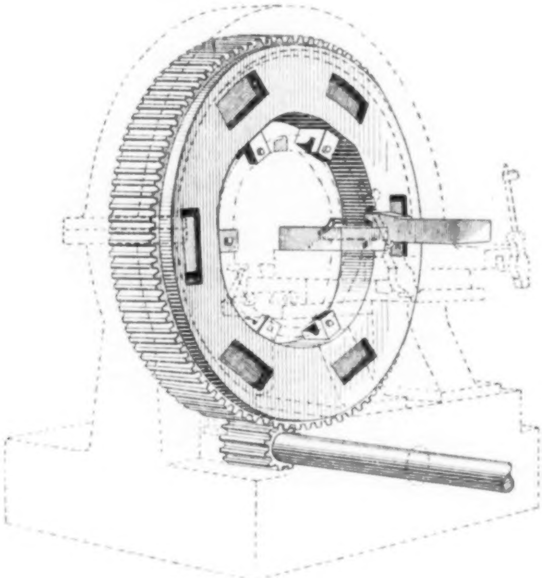


FIG. 14 MILL FOR BORING LOCOMOTIVE TIRES

the use of five elements, the courts will not ordinarily hold the latter machine to be an infringement of the claim. The inventor is bound by his statement of his invention to the extent at least that one who uses less elements than the claim states does not infringe.

35 If, however, Doe had made his claim read:

> I claim a machine consisting of the combination of a frame, means mounted on said frame for revolving a piece of work, guides on said frame and extending toward the position of the work, a part mounted on said guides, and a tool on said part, whereby said tool may be held against and guided along the said work for cutting the same.

he would have described his invention as truly as his more prolix claim including the turret, and yet he would have stated his invention so broadly that his claim would have described each one of the four subsequent machines quite as correctly as his own machine, for the claim would only be descriptive of the full-line parts of the five figures.

36 It will thus be seen that every invention is, so to speak, a soul incarnated in a body, and that the form of embodiment can usually be changed, and frequently infinitely varied without altering the nature of the soul. A further illustration would be to suppose, without irreverence, that some one invented the first animal having a vertebrated skeleton. All subsequent vertebrates would be embodiments of his invention, no matter how much more highly

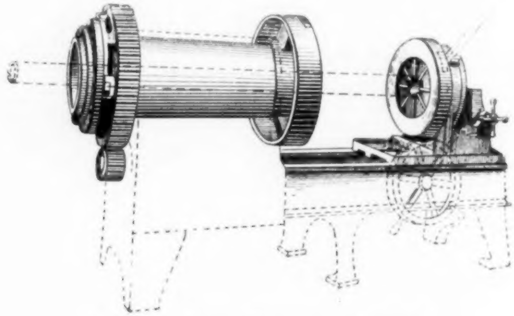


Fig. 15 Pipe Cutting Machine

developed they might be or how much adapted for different conditions of life, such as in water, or in the air, while the first vertebrate was adapted only for life on land.

37 It will thus be seen how vital it is that the one drafting the claim should be able to determine what is the soul of the invention, and to distinguish it from unessential details of the particular form of embodiment, and to express in the claim only the characteristics of that soul. It is also apparent that the less a claim says, the greater the monopoly granted by it.

PATENTING DOE'S METHOD OF TURNING LASTS

38 In analyzing the Doe method of turning lasts, for the purpose of drafting the claim, it was seen that there were essentially two steps: one, the forming of the rear, abutting, geometrical or hinge-

attaching surface on the toe part; and the other, the forming of the foot-shaped contour. Doe first forms the geometrical surface and afterwards forms the foot-shaped contour. The old method of forming the hinge last was first to form the foot-shaped contour and afterwards form the geometrical surface. It would appear, therefore, at first blush, that all Doe needed to protect him was a claim for the method of forming last parts which consists in first forming a geometrical or hinge-attaching surface on the blank, and then so supporting the model and the blank in the lathe that their corresponding geometrical surfaces should be parallel, and, finally, forming the foot-shaped contour on the blank by a cutter guided from the model. This would differentiate his invention from the prior art and would, apparently, protect its essence.

39 Doe was apprehensive, however, that some other way of making interchangeable last parts was possible than the one he had invented, and which would not be described by the proposed claim. Doe, therefore, analyzed the problem as follows: Any method of making a toe must consist of two steps, the forming of the geometrical surface, which we will call step A, and the forming of the foot-shaped contour, which we shall call step B. There are only three possible combinations or arrangements of these steps. A followed by B, B followed by A, and both steps together. This showed that all possible processes of making these last parts by cutting must fall within three generic classes, however they might differ as to details. Doe's method which he had already invented is an embodiment of the first type. The old prior art which could not produce the last parts interchangeable is an embodiment of the second type. If, therefore, Doe could invent an embodiment of the third type, he could absolutely monopolize all commercial methods of making the interchangeable last parts. He, therefore, set himself to invent an embodiment of the third type.

40 I will not cumber the paper by describing Doe's embodiment of the third type in detail with drawings, but will give simply a brief verbal description of it.

41 Doe arranged the face plate which supported the geometrical surface on the rear of the model toe so that that surface would be perpendicular to the axis of the spindle on which it revolves in the lathe. He then mounted the blank in any convenient way in the lathe and turned the foot-shaped contour in the usual way, by a cutter guided from the contour of the model, and then acted on the rear surface of the blank simply by running the cutter head straight

inwards toward the axis of revolution. This formed the rear surface of the new toe perpendicular to the axis of revolution and parallel to the similar surface on the model toe. While the new toe was supported on centres, Doe drilled holes where the screws were to go, and by means of these holes and the partially formed rear surface, he could place the toe, first in a machine for removing the nub where the centre supported the toe on its rear end and then in a machine for forming holes to receive the plug carrying the studs. The same principle was applicable to the forming of a heel.

42 This second, or alternative method, which Doe had thus invented might be commercially undesirable, but so long as it was physically possible to form interchangeable last parts by means of it, it was sufficiently an invention to make the basis of a valid patent and give Doe the second monopoly which he sought, namely, one to protect the third type, in which both steps were performed together.

43 Doe now set to work to see if he could not find a principle common to both of his types of method, and, if found, to draw for it. The result was the following claim:

> The method of forming last parts, which consists in providing a model having a toe and heel part, each having a regular surface, said surfaces having a definite geometrical relation to each other in the complete last, preparing a last part by providing a block with a regular surface, and turning a foot-shaped surface thereon by a cutter guided from the foot-shaped surface of the model, the cutter which last performs its operation on the block moving in a path having the same relation to the axis of revolution of the block as the corresponding surface of the model bore to its axis of revolution.

44 This claim does not state whether the geometrical or regular surface is formed before the foot-shaped contour, or after. It correctly describes any process in which one of the two surfaces on the new toe is formed and then the other of those surfaces is formed, while the first surface, be it geometrical or foot-shaped contour, is held parallel to the corresponding surface on the model. This, then, is an essence or soul common to both the Doe methods, and the single claim protects them both. The effect of Doe's final claim was to reduce his two methods from independent genuses to species of a single genus.

INFRINGEMENT

45 We will now consider how a court applies a patent as a practical matter in a suit for the infringement of it, by the making,

using or selling of an article which the patentee complains of as embodying the patented invention. If the competing device was a copy of the patented device, there would be no difficulty in reaching a decision. But those who seek to evade a patent seldom make Chinese copies of the patented device.

46 Suppose, then, for the purpose of illustration, that Doe had not foreseen the possibility of the third type of method of forming his toes and had not drafted his claim as broadly as the one quoted, but had drawn the following claim:

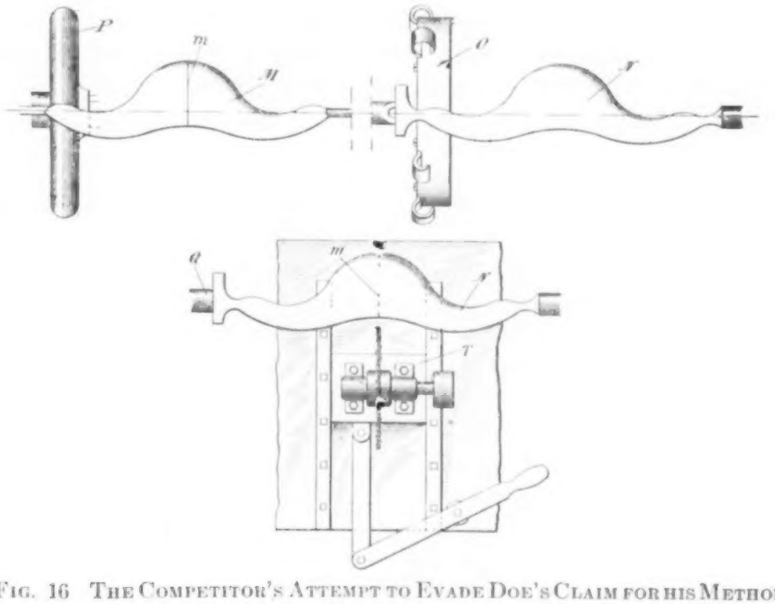


Fig. 16 The Competitor's Attempt to Evade Doe's Claim for his Methods of Turning Lasts

The method of forming last parts which consists in forming a geometrical surface on the blank corresponding to a geometrical surface on the model, so supporting the blank and the model in the lathe that such surfaces shall be parallel, and then forming the foot-shaped contour on the blank by a cutter guided from the model.

47 Suppose, now, a competitor then sought to evade the patent in the manner indicated in Fig. 16, that is, by forming a model M, consisting of two toes put butt to butt and turning a double blank N by a cutter O which is controlled from the model wheel P in the ordinary manner. Suppose the competitor mounted the blank upon

two centers Q and R, on a sawing machine having a circular saw S mounted on a carriage T traveling between guides, the saw being so placed with reference to the centres that it would saw the blank on a plane n exactly corresponding to the plane m of the model, thus making two toes in which the geometrical surfaces bear exactly the same relations to the foot-shaped contours as in the model.

48 This method of the competitor would avoid the narrower claim of Doe just quoted above, but would clearly infringe the broad claim first recited. Under our present supposition (that Doe had not discovered the possibility of the third type of method and had not drawn a claim broad enough to cover both types) he would be in the unfortunate position of having somebody utilize his discovery as a basis for doing the same thing in a different way and escaping his claim, and yet really using his invention after all.

THE DOCTRINE OF EQUIVALENTS

49 This is a situation which has frequently arisen in the courts, and the inequity of it has appealed to their sympathy. Claims are frequently unskillfully drawn, and the courts, in order to afford relief in meritorious cases, adopted what is known as the doctrine of equivalents, under which it is held that a patentee is not only entitled to what he claims, but to every equivalent of it. An equivalent is defined to be that which performs the same function in substantially the same way. This phrase, "substantially the same way," is indefinite and permits the court to do what it conceives to be equity in any particular case. If the invention is one of decided novelty and of great service to the public, the courts will hold almost anything which performs the same function as the patented element or combination to be an equivalent. If, however, the margin of novelty is small, the courts will require the elements or combinations to be almost identical with that specified by the claim to be an equivalent.

50 In the present instance, it would be argued that the essence, or soul, of Doe's invention consisted in forming a regular surface on the blank for the new toe and turning a foot-shaped surface thereon by a cutter guided from the foot-shaped surface of the model, the sole essential condition being that, whichever cutter last performs its operation on the block shall move in a path having the same relation to the axis of revolution of the block as the corresponding surface on the model bore to its axis of revolution. It will be observed

that the competitor carefully preserved the location of the axis of revolution in the block by preserving the centres and using the centres to position the block, so that the saw in forming the surface *n* moved in a path having the same relation to the axis of revolution of the block as the surface *m* of the model bore to its axis of revolution. This is the very condition, the lack of which made interchangeable last parts an impossibility by the prior art. For, in the old method the ends of the toe and heel were finished before the last was sawed to divide it into the toe and heel, and this finishing of the toe and heel destroyed the centres, so that the sawing was done by eye or guess-work.

51 It would be entirely in accordance with many previous decisions for the court to hold that Doe, having made an invention of decided novelty and commercial value, was entitled to a broad range of equivalents, and that although his claim was limited to the particular procedure by which he had illustrated his invention, namely, to forming first the geometrical surface and afterwards the foot-shaped contour, still the competitor's way accomplished substantially the same result in substantially the same way, because it utilized the essential condition above pointed out, and therefore, what the competitor did came within the monopoly granted by the patent and should be enjoined.

DEFENCES TO AN INFRINGEMENT SUIT

52 It would be open to the competitor to show that the patent to Doe was invalid for any one of a number of reasons. For instance, if the competitor could show that the invention was known or used by others in this country before the patentee invented it, the patent would be held to be invalid. If, however, as actually happened in the present instance, Doe's counsel, on cross-examining the competitor's witnesses, should show that the use of the invention before Doe's invention of it, was in secret, and only the necessary employees of the competitor were allowed to see it, and precautions were taken to preserve the knowledge of the method from the public, then the prior use would not be held to invalidate the later patent granted to Doe. The reason is that the object of the patent law is to induce inventors to give the public a knowledge of their inventions, so that the public may use the inventions after the patents are dead, and if a person keeps an invention secret, the public does not then get any benefit of it, and might never get any benefit of it,

since the knowledge may die with those possessing it. Therefore, the courts will not invalidate a patent to a subsequent original inventor because of an earlier secret use. If the competitor could show that the invention was in public use, or described in a printed publication for more than two years before Doe filed his application, no matter if it all occurred after Doe made the invention, and was Doe's own public use of the invention, or printed description of it, his patent would be held to be invalid. There are other defences which the competitor might raise, but these are the principal ones.

53 A patent, being a public grant, is presumed to be valid, and only the strictest proof of one of the defences will enable it to prevail against the patent.

CONTESTS BETWEEN RIVAL CLAIMANTS TO AN INVENTION

54 Without previously stating the principles by which contests between rival claimants to an invention are decided, I will illustrate them by a contest which occurred in the present development.

55 Doe conceived of his method of forming interchangeable toe parts, and filed his application for patent in the month, let us say, of June. He filed his application for patent without previously trying the method, or actually practising it, by the use of machinery. An interference, or contest, was declared between Doe's application for patent and an application of another party, whom we will call Richard Roe, which was filed in May. Roe, being the first to file his application, was presumed to be the first inventor, and the burden of proving he was not the first rested on all later comers, including Doe. While testimony was being taken in this interference, it was interrupted and re-declared, adding a third party, whom we will call John Mark, and whose application for patent was filed in November. It developed that Mark had filed an application for patent the previous year, and by failing to prosecute it with that promptness required by the Patent Office rules, it had become what the Patent Office terms abandoned or dead. Mark claimed that Roe had derived a knowledge of the invention from him (Mark), and that, therefore, Roe had never made the invention, in the sense that he had never generated it in his own mind, and so had wrongfully applied for a patent, as the law provides only for the granting of patents to actual inventors.

56 In determining these contests between rival claimants for a patent, the law considers an invention to consist of two steps: first, the mental conception, and second, the reduction to practice of that invention, or the embodiment of it in a form sufficiently perfect, so that the invention can be used by the public without any further exercise of the inventive faculty. The law considers the reduction to practice accomplished when either of two things has been performed by the inventor, or by those acting for him at his request. Either he must build a machine or an article of manufacture, if the invention be a machine or article of manufacture, or the apparatus or mechanism for practicing a method, if the invention be a method, and he must, ordinarily, demonstrate the perfectness of the machine, article or method actually by operating it. Or he may file an application for patent for the invention, and, if the examiners of the Patent Office decide that that application discloses an operative form of the invention, the filing of the application is considered equivalent to the actual reduction to practice by mechanism, and is technically known as a constructive reduction to practice.

57 In an interference contest, the original inventor who is the first to conceive the invention, and who follows his conception by substantially uninterrupted diligence in reducing it to practice, ending in a successful reduction to practice, either actual or constructive, is entitled to the patent. The law does not require that the first conceiver of an invention shall also be the first to reduce it to practice, so long as he connects his conception to reduce to practice by reasonable diligence. But, as before stated, the burden of proof as between any two contestants is on the later comer into the Patent Office.

58 A simple graphical diagram will be of assistance in settling the contest we are considering. In Fig. 17 is shown a diagram of the production of an invention. We will represent the conception by a vertical line, the reduction to practice by another vertical line, and the diligence in maturing the conception into a successful reduction to practice, by a horizontal line. A complete inventive act, therefore, will consist of two vertical lines connected by a horizontal line. An interruption, or delay in carrying out the reduction to practice will be represented by dotting that portion of the diligence line.

59 We are now in position to draw the diagram in Fig. 18, representing our contest for the patent. As Mark was the earliest to conceive the invention, his conception should occur farthest to

the left, being the date when he filed his first application for patent. The period between this date, and the filing of his second application for patent, being a period of inactivity should be represented by a dotted line, showing there was no diligence in reducing the invention to practice. When Mark began the preparation of his second application for patent, his diligence really began, and from then on to the filing of his application for patent, his diligence line is a solid line. As Roe derived his conception of the invention from Mark, we can give him no conception line, but simply a diligence line, ending in a constructive reduction to practice in the filing of application for patent. Doe, last of all, conceived the invention, and connected his conception, by reasonable diligence, with his constructive reduction to practice in filing the application for patent.

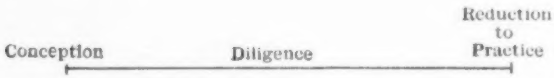


FIG 17 DIAGRAM OF THE PRODUCTION OF AN INVENTION

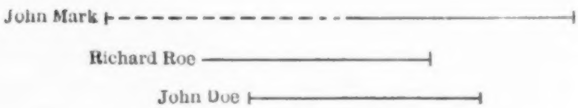


FIG. 18 DIAGRAM OF THE DOE VS. ROE VS. MARK CONTEST FOR THE PATENT

60 As Roe never performed the complete inventive act, since he never conceived of the invention himself, he was not entitled to a patent, even though he did file an application for a patent on the invention earlier than Doe's application, and earlier than Mark's second application, therefore it is either Mark or Doe who will be entitled to the patent. As Mark's first application for patent became abandoned, the law only regards it as evidence of conception of the invention, and neither as evidence of diligence, or reduction to practice. As Mark was, therefore, as the courts have termed it, "sleeping on his rights" at the time Doe entered the field, Mark is restricted to the date when he filed his second application for patent, which, in effect, makes his conception of the invention later than Doe's conception of the invention, the law regarding it as though Mark had never conceived the invention until he filed his second application for patent. This makes Doe the first of the three to conceive

the invention, and as Doe diligently followed his conception by a constructive reduction to practice, he was legally the first inventor and secured the patent.

61 While it is impossible, within the limits of such a paper as the present one, to give a complete statement of all the fundamental principles of the patent law, the purpose of the paper has been accomplished if it has given an intelligible understanding of a sufficient number of those principles to put the engineer and manufacturer on his guard, so that he may know what can be accomplished, and when, and how to utilize his counsel in such matters.

TAPS AND SCREWS

At the meeting of the Society held in New York, March 12, 1912, a paper by F. O. Wells of the Wells Brothers Company, Greenfield, Mass., was presented by H. E. Harris, testing engineer for the company, on Taps and Screws.

The average user of machine screws and bolts hears very little about the finely drawn theories in regard to angles and other details and their practical application to tap and die making. The ability to buy or make screws and bolts which can be depended upon to fit the tapped holes in the product under manufacture is, however, a matter which demands attention. Differences in the dimensions of the screws and the tapped holes must be made in order to allow for unavoidable imperfections in manufacture and wear on the taps and sufficient freedom of fit, but this should be confined to such small limits that the smallest permissible diameter for the taps will be slightly larger than the largest permissible diameter for the screws. If these limits are too large, a screw which happens to be used in a hole tapped by a maximum sized tap may be too loose. The limits must be closely guarded; but at the same time they must not be so small as to prevent an interchangeable assembling, and must also allow for a reasonable amount of wear on the tap.

The two factors most vital in this connection are the size and the lead. It is very important to understand how the size is to be measured. The fit of any screw should be on the sides of the angle of the thread, as the outside and root diameters have comparatively little to do with the actual fit; for, unless the angle and the lead of the threads are the same in both screw and tapped hole, and the diameters measured across the angles of the threads are relatively right, a proper fit can not be obtained, no matter how close to size the outside and root diameters are held.

Fig. 1 shows one effect of fitting together nuts and screws of different angles. In this case the screw is shown with a more obtuse angle than the nut, and the bearing between them, if one could be

obtained this way, would be on the sharp, fragile apexes of the teeth.

The necessity of measuring the angle accurately has led to the adoption of the term pitch diameter for screw threads, as well as for gears, and those who have gone carefully into the study of screw threads are using exclusively this method of measuring.

Fig. 2 shows a micrometer which measures these important diameters across the angle. The great merit of this particular tool is that it is not rendered inaccurate by the helix angle of the thread; that it will measure the finest lead thread as well as the coarsest within its range, and that it has the greatest range that has been developed.

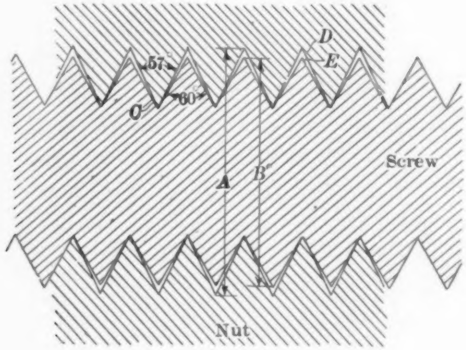


FIG. 1 EFFECT OF FITTING NUTS AND SCREWS OF DIFFERENT ANGLES TOGETHER

Fig. 3 shows how variations in the lead affect the pitch of a screw. The angle in this case has been assumed to be correct, but the nut has been tapped with a tap having long or stretched lead, with the result that a bearing can be had only in two places at the most, as indicated by AD and BC.

This is not by any means an exaggerated condition and explains the reason why a nut, tapped with a large diameter tap, will often start freely on a screw, turn a few turns, gradually becoming less free, and then bind. It has then found its AD and BC and cannot move further, because the position of the bearing on opposite sides of the thread acts as a wedge.

While it is possible that on small work and with soft metals, screws might be put together in this way, it is very evident that it

would not be a good job and would very soon prove unsatisfactory. It would also tend to place all the strain on one tooth at a time, making it possible, under a sufficient longitudinal strain, to strip one tooth after another with a shearing action, at a small percentage of the power that would be required to strip them all simultaneously when the lead is correct.

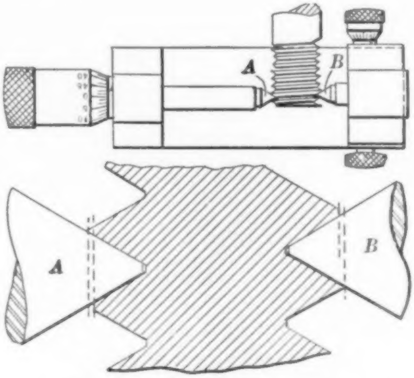


Fig. 2 Micrometer for Measuring Diameter of Screws Across the Angle

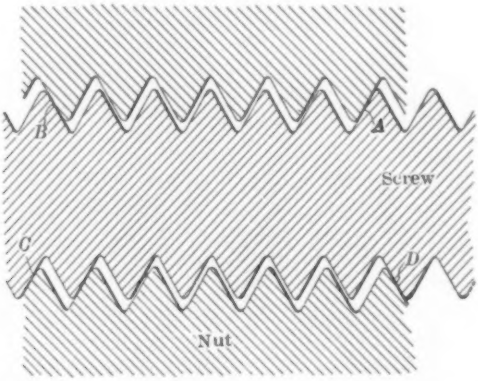


Fig. 3 Effect of Variation in Lead upon Pitch of Screw

As stated, the user generally desires only to have his screws and bolts fit satisfactorily. Those who do a large amount of assembling, where thousands of screws of various sizes are used, know the difficulty of this proposition. They are acquainted with the variation to be found in machine screws, as well as in the tapped holes, and with the delay which this makes in assembling, as well as with the

difficulty of supplying duplicate parts. For this reason, many are using point limit gages especially made to measure the screw diameters across the angles, and so insure the uniformity, within working limits, of the screws to be used.

FIG. 4 POINT LIMIT GAGE

FIG. 5 SCREW CARRIED DOWN TO MINIMUM LIMIT IN POINT LIMIT GAGE

Fig. 4 shows one of these gages in use. The screw being measured has just been passed on the "go," or maximum limit, and with the same movement is carried down (see Fig. 5), to the "not-go," or

minimum limit. The screw being inspected in these two figures is evidently a good one, since it passed between the go, but will not pass between the not-go points.

The rapidity and accuracy of this method of measuring threads is partly apparent, but its great efficiency may be better realized if actual figures are given. An inspector of $\frac{1}{4}$-in. taps for limits on angle and outside diameters with two limit gages of this style, will gage about 750 per hour. For ordinary screw work, not requiring such extreme care, the output might be even greater.

As to the lead of taps, there is little doubt that most makers use a somewhat similar method to secure uniformity of product. It must be remembered, however, that as all steel expands and contracts with heat and cold, taps change their lead to some extent in the hardening process. If, in addition to this, they are warped on

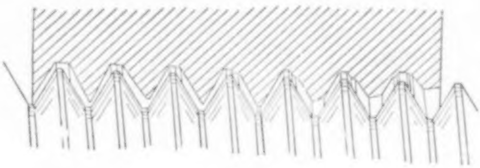


FIG. 6 NUT TAPPED WITH TAP WARPED IN HARDENING—STANDARD THREAD

the threaded end, the lead, the angle and diameter of the tapped hole will be affected, as can be seen in Fig. 6.

To what has been said of the effect on taps of errors in lead, angle, angle diameter and warping, must be added the effect of usage in reducing the size of the tap by wear, as well as the commercial variations of lead, angle and diameter in the screws or bolts, and it will readily be seen that under the best possible conditions there will be a multiplicity of minute errors that will have to be taken care of by the allowance between the minimum limit of the tap and the maximum limit of the screw. There will also have to be a maximum limit set on the tap and a minimum limit set for the screw, to provide for manufacturing allowances and to prevent too much looseness in the fit of the thread.

There is great diversity of opinion at the present time among tap and die makers, and screw makers in general, as to what these allowances should be, and what constitute the correct limits for the taps and screws of the U. S. Standard sizes, with the result that a buyer or manufacturer has trouble in securing taps to suit his screws, or

screws to fit his tapped holes, and is working under a serious handicap in his efforts towards proper fits and interchangeable work.

The Committee of the Society on the Standard Proportions of Machine Screws gave, in its report of 1907, a list of standard machine screw sizes, with diagrams and tables of standard proportions, limits for screws and taps, sizes of references, gages, etc., which received the endorsement of, and has been of unlimited value to, the industrial community at large. The question of limits for the larger size screw threads was, however, left unsettled, and this question, from its far-reaching nature, is too large a matter to be settled by either the manufacturer or the user.

In order to determine some of the conditions under which the tap has to work, such as proper sizes of tap drills, best lubricants, the correct cutting angles and shapes of flute, the right number of threads among which to distribute the cutting, the best methods of tempering to increase the life and strength of taps and prevent undue distortion and shrinkage, etc., Wells Brothers Company have had special testing machines built for showing the power required to drive a tap, and for recording the tap's cutting action on indicator cards or charts.

It is often found, in cases when one would least expect it, that a manufacturer is actually punching or drilling holes for tapping of a smaller diameter than the root diameter of the thread, so that the end of the tap must act as a reamer before the thread can be cut. In this case the tap becomes a taper reamer with unrelieved chip breakers, and reams a taper entrance to the hole. Oftentimes it will fail to "catch the thread" at all, and will therefore ream clear through or to the bottom without threading. Or, if the thread does happen to catch after reaming part way through, a short, weak thread is the result.

This requires considerable power, often beyond the breaking strain, and explains why taps sometimes refuse to cut a thread at all, and also why taps sometimes break almost as soon as they begin to cut. When it is remembered that, generally speaking, more than 80 per cent of the standard thread depth is never necessary in manufacturing, even for shallow holes, and in many cases not more than 50 per cent, the folly of having holes too small can be seen, and, in most cases, even of attempting to secure a full thread.

Tap drill sizes for machine screws in particular, should be varied according to the material to be tapped, and the depth of the tapping.

Roughly stated, for holes that have the screws enter more than $1\frac{1}{2}$ times the diameter, 50 per cent or half thread is usually sufficient, as the head will break off, or the screw will stretch or break before the thread will strip.

Soft, tough material, such as copper, Norway iron, drawn aluminum, etc., should have a larger hole for the tap than the harder and more crystalline materials, such as cast metals. This is because, if they are drilled smaller, the tops of the threads are liable to be torn off, which decreases the effective depth of the thread in the tap hole, and results in a poorer thread than if the hole had been originally drilled a little larger. On the other hand, in these more tenacious ductile materials, if the hole was originally a little large, the tap,

Fig. 7 Three Taps with Different Fluting

especially after the keen edge has become slightly dulled by use, will reduce the size of the hole by spinning or drawing the metal at the tops of the threads, thereby increasing the effective depth of the thread.

It should also be remembered that it is impracticable to tap a hole with the basic root diameter size, unless the much slower processes, with serial taps, or long step taps, are used, so as to divide the tapping operation into a series of successive steps, each removing a small amount of metal. The size of the hole also affects very materially the power required for tapping, and the tap breakage. This is particularly important in machine tapping, which is the main thing to be considered in manufacturing. The power is also affected by the kind of lubricant used, by the condition of the tap, whether sharp or dull, by the shape of the cutting edges and their effect on the shape and action of the chip, and also by the spaces allowed for chip clearance.

Fig. 7 shows three taps with different fluting. The tap at the

middle produces a long curling chip, which, in a deep enough hole, would have sufficient length to curl up tightly, jam the tap and cause the tap to twist or break off, if there was sufficient driving power. The chips are shown on Fig. 8. The length, the curled twisted form, and the large percentage of tightly curled chips should be noted.

Fig. 11 shows nuts in which long curled chips have rolled up and broken the tap. Note, however, the clean, smooth thread. As

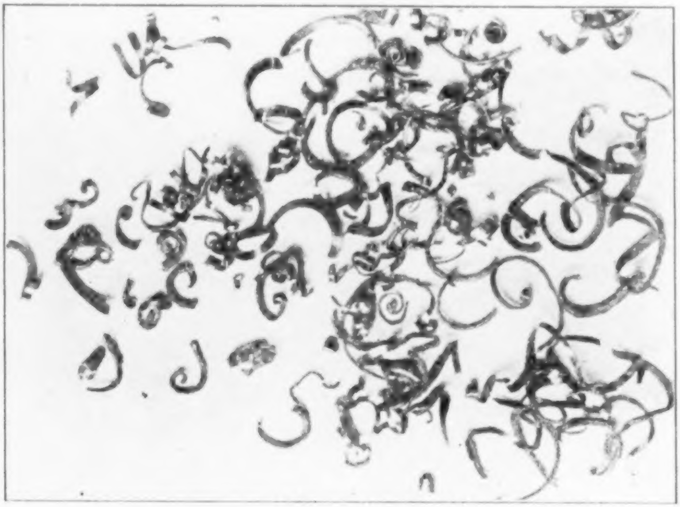


Fig. 8 Chips made by the Tap at Center of Fig. 7

shown in Fig. 7 the tap at the right tears and pushes the metal ahead of it, often accumulating enough compressed unseparated metal to resist further compression and break the tap. This tap broke while tapping cold-punched nuts, at 1100 in-lb., twisting off near the shank, in spite of the fact that the work was divided among 48 cutting teeth.

The chips from this tap are shown in Fig. 9. Their compressed character should be noted; in fact, they show by their appearance the relatively large amount of power and increased breaking strain required on the tap.

Fig. 12 shows the sections of four nuts tapped with this kind of tap, and in tapping which, the taps broke. The compressed and mashed-together mass of metal adhering to the thread, and the torn

condition, are noticeable. When four of these obstructions accumulate in one tapped hole, one for each land, the tap is apt to give out.

In Fig. 7 the tap shown at the left not only cuts a free, slightly

FIG. 9 CHIPS MADE BY THE TAP AT RIGHT OF FIG. 7

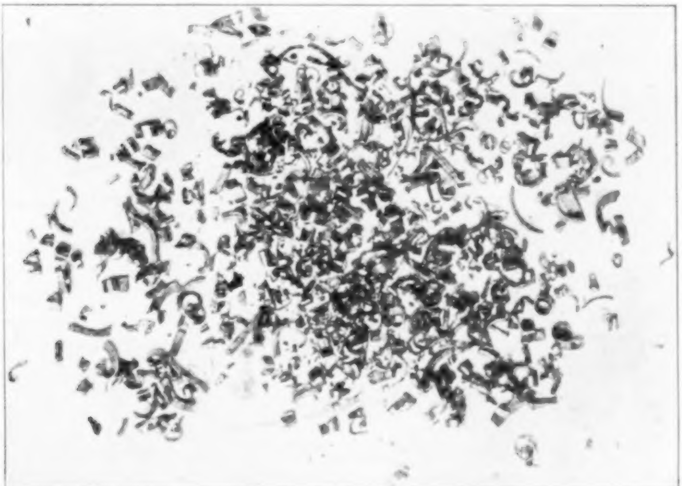


FIG. 10 CHIPS MADE BY THE TAP AT LEFT OF FIG. 7

curling chip, but will break the chip into short lengths that will readily slide out of the way along the flutes when pushed by the successive chips, or carried by the lubricant. It uses about one-third of the power, on an average, that the tap on the right does.

The chips cut by such a tap are shown in Fig. 10. They are free-cutting and short and the tap works under much less strain than with the other forms of fluting, as continued tests with different forms and in various metals have proved.

Fig. 13 shows a section of a nut in which this last style of tap was started and then the nut was cut open to show the action of the chip.

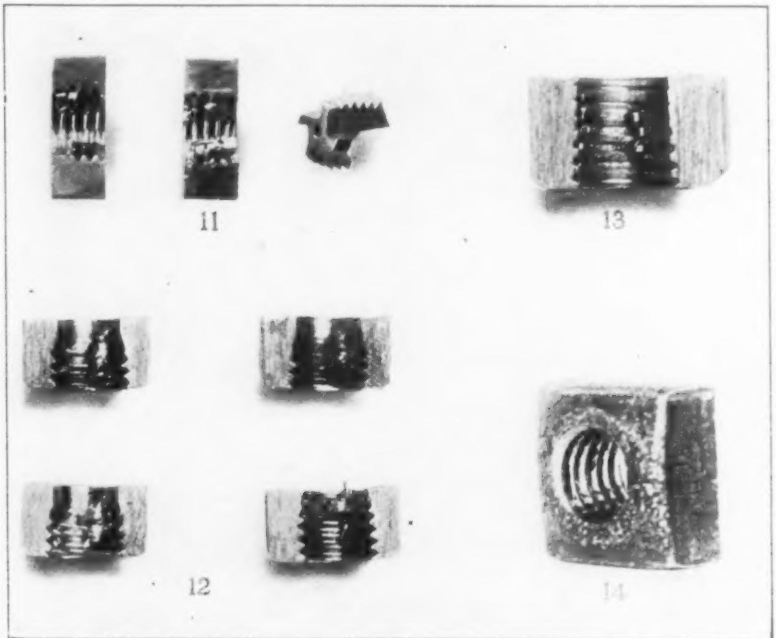


Fig. 11 Nuts in which Long Curled Chips have Rolled up and Broken the Tap
Fig. 12 Sections of Four Nuts Tapped with Tap Broken at 1100 In-Lb.
Fig. 13 Section of Nut where Chips are Broken into Short Lengths by Tap
Fig. 14 Chattered Nut

The smooth thread and clean, short curl of the chip which was on the point of breaking should be noted.

As almost all machine tapping is in through holes, and the uses of the bottoming tap are extremely few, experiments were made on the effects of sharpening or grinding the taps back from the end for a varying number of threads, so as to ascertain the effect of dividing the work among more or less cutting teeth. It was found by

repeated tests and careful record, that it requires approximately 25 per cent more power to drive a tap which has been ground back but four threads, which, in a four-flute tap, divides the cutting among 16 teeth, than for one which has been ground back six threads and having 24 cutting teeth. The 24 cutting teeth also gave much smoother threads, and cut more closely to size. This shows that for general use, a tap ground back six threads works better and will last longer than one ground back only four.

Fig. 14 shows a very badly chattered nut, the chattering being caused by burrs thrown up on the cutting edges of the tap during its manufacture; this has the same effect on the cutting edges of the tap that relieving or backing off the threads would have; that is, it cuts large and rough, and jumps from side to side.

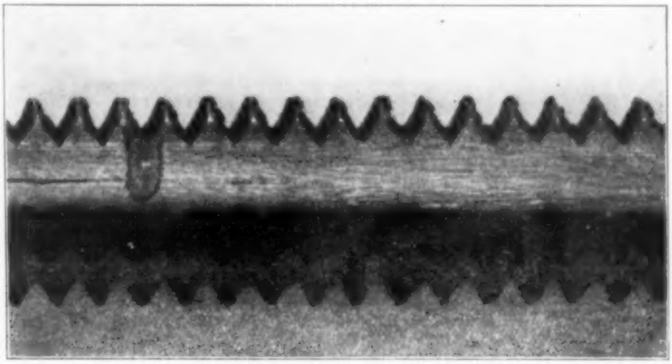


Fig. 15 Burrs thrown up on Cutting Edges of Tap, Causing Chattering of Nut

Fig. 15 shows a magnified view of these burrs. This shows the necessity of having taps free from burrs and great attention has to be paid to this point in order to produce good taps.

The effect of different materials upon the power required for tapping is shown in Table 1, which gives a chart of the results found on 14 different taps tested on test pieces of five different materials. The maximum and minimum power required by each tap when tapping consecutive test pieces is given in inch-pounds. It will be seen that drawn brass required, on an average, 65 in-lb. and is very uniform, and that while crucible steel is also a uniform cutting material, it required an average of 261 in-lb. or four times as much; cold punched hexagon steel nuts required an average of 190 in-lb.,

and hexagon screw stock, tapped endwise, 197 in-lb. Phosphor bronze shows the biggest power variation for the same tap, or throughout the test. It required an average of 228 in-lb. Taps Nos. 6 and 8 had a slightly poorer form of flute than the rest, and did not cut as smoothly nor as easily, as may be seen by referring to the power readings in the table

TABLE 1 VARIATIONS IN THE ACTION OF TAPS ON REPETITION TESTS IN DIFFERENT MATERIALS

TAPS USED ½ - 13 U. S. S. ROOT DIAMETER OF TEST PIECES 0.420 IN. DEPTH OF TAPPED HOLE ½ IN.

	Test Nos. of Taps													
Materials used	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Hexagon drawn brass	60	62	62	60	65	70	60	90	60	60	60	60	60	65
	65	60	65	60	65	80	60	95	62	60	60	62	65	65
Crucible tool steel	220	242	250	230	240	280	250	375	210	270	260	270	260	258
	225	265	268	250	230	260	235	380	205	280	275	260	260	270
Cold punched hexagon steel nuts	148	158	168	170	155	150	150	340	165	195	165	175	148	180
	130	130	175	190	160	180	132	360	140	160	225	200	180	180
Hexagon screw stock	140	150	165	188	178	180	155	250	140	240	235	168	225	230
	160	170	185	165	210	268	170	430	155	190	200	160	205	205
Drawn hexagon phospor bronze	210	175	250	200	230	240	170	338	160	200	220	222	265	210
	190	200	300	250	200	250	182	320	190	330	210	245	205	210

The above values represent the power required in inch-pounds to drive the taps through the test pieces as measured on testing machine.

Table 2 shows the effect of varying the root diameters and using different lubricants.

In this table, which is the final result of a long series of tests, the breaking strain is taken for comparative purposes, as a 100 per cent strain (the power required to break a properly made ½-13 U. S. S. plug tap is approximately 1000 in-lb.), and the lesser strains required for tapping holes under different conditions are given as percentages of this. The test pieces used were common hexagon cold punched nuts accurately reamed to the respective drill sizes, and the taps used were regular stock ½-13 U. S. S. taps.

The points which this series of tests seem to emphasize particularly are as follows:

a That the lubricants used, up to a certain point, have the

TABLE 2 EFFECTS OF VARIOUS LUBRICANTS AND DIFFERENT TAP DRILL DIAMETERS ON THE CUTTING ACTION AND BREAKING OF TAPS

Lubricant	Animal Lard Oil, per cent	Sperm Oil, per cent	Graphite, 10 per cent Tallow, 90 per cent	Cataract Cutting Compound, per cent	Mineral Lard Oil, per cent	None, per cent	Machine, per cent
0.425 in. Diameter of Tap Hole, 75 per cent Thread							
Per cent of breaking strain	15.9	16.5	16.9	18.9	19.9	29.9	34.2
Breakages in tests	None	None	None	None	None	14	15
Quality of thread cut	Smooth	Smooth	Smooth	Smooth	Smooth	Rough	Torn
0.410 in. Diameter of Tap Hole, 90 per cent Thread							
Per cent of breaking strain	....	23	....	25.1	36.5	60.2	68.5
Breakages in in tests	....	None	....	None	None	50	71.5
Quality of thread cut	....	Smooth	....	Smooth	Smooth	Rough	Torn badly
0.400 in. Diameter of Tap Hole, 100 per cent Thread							
Per Cent of breaking strain.	....	35.5	....	41	57.5	71.8	100
Breakages in tests	....	None	....	None	None	66	100
Quality of thread cut	....	Smooth but with tops torn	....	Slightly rough with tops torn	Smooth but with tops torn	Torn and partly stripped	Torn and wedged so as to prevent tap cutting through

NOTE—By multiplying the above percentages by 10, the actual average power required in inch-pounds may be obtained.

same effect on the cutting power required as more or less metal to remove should have. For instance, to tap a $\frac{1}{2}$-in. nut with a 0.425-in. tap hole, using machine instead of sperm oil, would have practically the same effect on the power required, as reducing the diameter of the tap hole 25 per cent of the double depth of the thread. Referring to Table 2, it will be seen that the power is approximately double in both cases, from 16.5 per cent to 34.2 per cent on changing from sperm oil to machine oil, and from 16.5 per cent in the sperm oil column, to 35.5 per cent changing from a 0.425-in. to a 0.400-in. tap drill hole.

b That animal lard oil, sperm oil and the graphite and tallow mixture are the best lubricants of those tested.

c That a good cutting compound is better than some mineral lard oils for the purpose of tapping.

d That machine oil is a detriment instead of a help; that taps will cut better dry than with it.

e That the number of breakages can be greatly reduced by the use of a proper lubricant, and that taps should never be used dry in steel.

f That the diameter of the tap drill hole should not be any smaller than is absolutely needed to give the necessary strength, and that if this requires a full depth of thread on any particular size, it would be advisable, from a tapping standpoint, to gain strength by using a larger size of thread in combination with an over-size tap hole

g If for any reason it is desirable to produce a thread having the full depth, in order to prevent breakage of taps and the tearing of the tops of the threads (which ultimately increases the size of the tap hole), serial taps should be used with the best lubricant obtainable.

h That every decrease of 0.001 in. in the diameter of the tap hole, materially increases the power required to tap it, and also increases the percentage of broken taps; and that as the tap hole gets smaller, the power required increases and the breakages occur in increasing ratio.

Referring in Table 2 to the sperm oil column, it will be seen that the decrease of 0.015 in. in diameter from a 0.425-in. to 0.410-in. hole required only 5 additional in-lb. in power, or an average of a little

over 4 in-lb. per 0.001 in., while the decrease of 0.010 in. from 0.410 in. to 0.400 in. required 125 additional in-lb. increase in power, or an average of 12.5 in-lb. per 0.001 in.

In concluding the author stated that he had presented only a small part of the tapping proposition; and that the item of greatest universal interest among tap and screw makers and users in general is the question of the adoption of standard limits for the manufacture of screws and taps of the U. S. Standard sizes.

DISCUSSION

In the discussion which followed the reading of the paper, F. G. Coburn[1] stated that while on duty at the Mare Island Navy Yard, in California, he succeeded in getting the Navy Department to adopt the Society standard for machine screw taps and dies as well as that for machine screws; previously there had not been a single first-class, high-grade tap in the whole Navy Yard. There is one more important step to be taken in the case of machine screw taps, namely that of standardizing the shanks and shank squares. Now a great deal of time is lost, and confusion caused, because some of the machine screw taps will not go through the holes, the square or section not being of the right size. Something must also be done for the hand taps and tapper taps, dies for bolt machines, etc. A large loss is now caused by nuts bought from one manufacturer not going on bolts bought from another, or by tapper taps making in the nut machine nuts which will not go on a bolt drawn from the store room.

W. R. Porter described the method of measuring threads used by the S. S. White Dental Manufacturing Company.

George W. Adams[2] described the screw and tap situation in the Camera Works of the Eastman Kodak Company, at Rochester, N. Y. The particular requirements of the construction of the photographic camera demand a very high accuracy of the screw and enforce the use of a very fine thread. About 15,000,000 screws are produced, and while some of the screws run as large as 1.330-40, the screws used most are 0.060-90 and $\frac{1}{16}$-72, the former size being used principally on the shutter in which is mounted the lens. Mr. Adams sets the following limits on this 0.060-90 screw:

[1] Assistant Naval Constructor, League Island, Philadelphia, Pa.

[2] Eastman Kodak Co., Rochester, N. Y.

Minimum screw 0.059
Maximum screw 0.060

This allows 0.001 in the manufacture of the screws. The tap makers are allowed

0.001 over the basic for the minimum tap
0.0015 over the basic for the maximum tap

This gives 0.0025 between the largest tap and the smallest screw, and allows 0.001 wear on the minimum tap before the gage will be tight in the hole tapped.

It requires considerable attention on the part of the operator to hold these sizes, but Mr. Adams believes it to be practical. He has made some tests on taps in the past few weeks, and found that he could tap on an average 6100 holes through 0.040 sheet brass, which he considers to be a good record for such a small tap. No stream of oil is used on the tapping machines, as many of the parts are plated before tapping. This is done to prevent the nickel filling up the holes or decreasing them in size. In place of oil a special lubricant is used made by W. J. Foul, of New York. It resembles bees-wax in consistency, but Mr. Adams stated that he is experimenting with an air brush, so connected with the tapping machine as to throw a very fine spray just before the tap enters the work.

In the manufacture of small screws the dies play a very important part. The Acorn die was found to give the best results, with the die in many cases ground on the face, reducing the lead from 3 threads to 1 thread, so as to allow a full thread very close to the head of the screw. This has been found to be more efficient than using a small pencil and grinding internally on the edge of the teeth.

In closing his remarks, Mr. Adams called attention to the obligation laid upon the tap manufacturer to educate the public in the methods of measuring taps; to do this, information should be given in catalogues so that the ordinary workman in the shop can understand how to make a tap for a screw, and how to measure it. There are now many shops, and big shops at that, in which there are no suitable instruments for measuring taps.

E. Howard Reed said that he had found in many screw threads, especially in the nut, that the standard as adopted by the Society does not allow the manufacturer sufficient leeway. The machine screw nuts are made much thinner in proportion to the diameter of the screw than are the standard sizes of nuts, with the many frac-

tional sizes. On that account it might seem that it was much easier to tap the nut and get a full thread in it than it would be to tap a U. S. Standard nut. This is undoubtedly the case, but at the same time it is necessary to make the machine screw nuts very quickly. The price of the product does not admit taking much time in the process of tapping.

About $\frac{7}{8}$ full thread is put in, but so far no complaints have been received on account of the nuts being made with too little thread in them; in fact, that is as near as it is found possible to go commercially.

Horace K. Jones suggested the use of the following method for finding the outside diameter of a screw of a certain number, viz., to multiply the number by 0.013, and subtract 0.06.

Charles B. Russel[1] discussed the commercial value of adopting a U. S. Standard thread, and doing away entirely with the V-thread, to which end tap manufacturers have been working for a number of years. To determine the progress of the adoption of the U. S. Standard thread, the speaker looked up his sales of taps for the past year, taking the two types, the tapper tap and the ordinary hand tap, which are used by machinists for various purposes, and found 93 per cent of sales in the U. S. Standard against 7 per cent in the V-form. Letters from fifteen of the most prominent manufacturers of bolts and nuts, and of cap and set screws, have shown that the average output in bolts and nuts was 99 per cent in the U. S. Standard form of thread against 1 per cent in the V-form, which shows practically a complete adoption of the U. S. form of thread; in taps and screws, however, the output was only 53 per cent of the U. S. Standard form of thread against 47 per cent in the V-form of thread.

J. E. Winter[2] spoke of the trouble manufacturers sometimes have with customers who judge a tap by its outside diameter, mainly because the ordinary outside micrometer is the only instrument the manufacturers have; as a matter of fact, customers would get more wear out of a tap that is slightly oversize. As regards lubrication, cotton seed oil is both cheap and very good; if it is gummy when put on the machine, the application of a little kerosene oil will overcome that difficulty.

[1] Wiley & Russel, Greenfield, Mass.

[2] Winter Bros., Wrentham, Mass.

George B. Pickop suggested in regard to the adoption of U. S. Standard for thread diameters, that it would be a good thing to add to those diameters already established the standardization of the diameters of head and thickness of head, and width of slots in screws of the U. S. Standard, and also the length of thread cut on the body of the screw. These items ought to be fixed as well as the other diameters.

The V-thread cannot be abandoned on pipe threads, as the flattening of the top of the thread and the changes in the tap diameters and possibly die diameters might leave a space at the outside diameter which would present a starting point around the taps and cause leakages in the fittings.

F. O. Wells said that one of his experiments with an ordinary commercial tapper showed that it has a factor of safety of only 2 when new; when dull, he does not know what the factor of safety was. He had further found that a small shank tap is very nearly as strong as a large shank tap. He also mentioned that oil of some kind with a soapy body will make a difference in the size of the screw. With the same die there will be a difference of 0.007 to 0.008 in. between the sizes of a screw made with lard oil, and one made with a soapy compound.

C. B. Buxton[1] wrote that one of the greatest troubles of the present time is the question of obtaining the proper lead on screw parts, such as dies; this is not readily detected because the usual gages are not of any considerable thickness, but becomes very noticeable on many automobile parts, due to the internal member being threaded to such a length as to permit adjustment, and a screw that is cut to gage will not enter more than double its diameter before there occurs an interference, even when the tap cutting mating member is correct to pitch and lead.

On some alloys of aluminum, due to their peculiar character, the hole is increased, not by the cutting edges of tap, but by the natural flowing of the metal away from the point.

Table 3, while not entirely free from error, was compiled mainly from the condition actually observed of the thread after being tapped, and has been successfully used for five years.

[1] Tool Supervisor, American Locomotive Company, Providence, R. I.

Wilfred Lewis. The U. S. standard V-thread, flat top and bottom, should be adopted, I think, not only for pipe, machine and boiler work, but also as a universal world standard for all kinds of binding screws. I do not think this form of thread can be improved upon, but it is generally admitted that the U. S. standard pitches in

TABLE 3 SYSTEM FOR THREADS USED BY AMERICAN LOCOMOTIVE COMPANY

Size	Thread	Body Drill In.	Tap Drill for Steel Forging / Steel Casting	Tap Drill for Cast Iron / Malleable Iron	Tap Drill for Aluminum / Brass	Size	Thread	Body Drill In.	Tap Drill for Steel Forging / Steel Casting	Tap Drill for Cast Iron / Malleable Iron	Tap Drill for Aluminum / Brass
4-36	V	32	42	43	44	½″-13	U.S.S.	33/64″	27/64″	Z	13/32″
4-40	V	32	41	42	43	½″-18	Fl.	33/64″	7/16″	27/64″	27/64″
6-32	V	27	32	33	34	½″-20	A.L.A.M.	33/64″	29/64″	7/16″	7/16″
8-32	V	18	27	28	29	½″-30	Fl.	33/64″	15/32″	29/64″	29/64″
10-24	V	9	23	24	25	9/16″-12	U.S.S.	37/64″	31/64″	15/32″	15/32″
10-32	V	9	20	21	22	9/16″-18	A.L.A.M.	37/64″	33/64″	½″	½″
12-24	V	1	15	16	17	9/16″-20	Fl.	37/64″	33/64″	½″	½″
14-20	V	¼″	10	11	12	9/16″-24	U.S.S.	37/64″	33/64″	½″	½″
14-24	V	¼″	6	7	8	5/8″-11	U.S.S.	41/64″	17/32″	33/64″	33/64″
¼″-20	U.S.S.	17/64″	9	10	11	5/8″-18	A.L.A.M.	41/64″	37/64″	9/16″	9/16″
¼″-24	U.S.S.	17/64″	4	5	6	11/16″-16	A.L.A.M.	45/64″	5/8″	5/8″	39/64″
¼″-28	A.L.A.M.	17/64″	3	4	5	¾″-10	U.S.S.	49/64″	41/64″	41/64″	5/8″
¼″-32	U.S.S.	17/64″	7/32″	3	4	¾″-16	A.L.A.M.	49/64″	11/16″	11/16″	43/64″
5/16″-18	U.S.S.	21/64″	¼″	D	C	¾″-18	U.S.S.	49/64″	45/64″	11/16″	11/16″
5/16″-24	A.L.A.M.	21/64″	H	17/64″	G	7/8″-9	U.S.S.	57/64″	49/64″	¾″	¾″
5/16″-32	V	21/64″	9/32″	J	I	7/8″-12	U.S.S.	57/64″	51/64″	25/32″	25/32″
3/8″-16	U.S.S.	25/64″	5/16″	N	19/64″	7/8″-14	A.L.A.M.	57/64″	13/16″	51/64″	51/64″
3/8″-18	U.S.S.	25/64″	O	O	5/16″	1″-8	U.S.S.	1 1/64″	7/8″	55/64″	27/32″
3/8″-24	A.L.A.M.	25/64″	Q	21/64″	P	1″-12	U.S.S.	1 1/64″	59/64″	29/32″	29/32″
7/16″-14	U.S.S.	29/64″	U	U	S	1″-14	A.L.A.M.	1 1/64″	15/16″	59/64″	29/32″
7/16″-20	A.L.A.M.	29/64″	25/64″	W	3/8″	1″-16	U.S.S.	1 1/64″	15/16″	15/16″	59/64″
7/16″-24	U.S.S.	29/64″	X	25/64″	W	1″-18	U.S.S.	1 1/64″	61/64″	15/16″	15/16″
½″-12	U.S.S.	33/64″	27/64″	Z	13/32″						

small sizes are too coarse, and I see no reason why the U. S. standard should not be revised.

An important advantage of the U. S. standard over the machine screw standard is that the former runs in sizes which can not be forgotten, while the latter runs in sizes which can not be remembered, and this difference marks the advantage due to a natural system of binary subdivision over a decimal system, with its long and short

jumps in spacing. Another point to be considered is the advantage of giving the odd sizes, as for example $\frac{9}{16}$ and $\frac{11}{16}$, the same pitch as the more common $\frac{1}{2}$ and $\frac{5}{8}$ sizes. Then, when a thread is stripped, a full thread can be tapped a little deeper in the same hole and an expensive casting need not be thrown away. At present this is seldom possible because the next size larger is generally of a different pitch.

The sizes $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$ and $\frac{7}{8}$, stepping up by $\frac{1}{8}$, form a group well spaced and convenient for all practical purposes between $\frac{1}{2}$ and 1, and to obtain larger or smaller standard sizes, I would simply multiply or divide these sizes by two. For instance, I would have $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, $\frac{7}{32}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$ for machine screw sizes, and split the differences for extra sizes which would have the same pitch as the next size smaller in every case. Between $\frac{1}{2}$ and 1, the extra sizes would be $\frac{9}{16}$, $\frac{11}{16}$, $\frac{13}{16}$ and $\frac{15}{16}$, and continuing to larger sizes, the standards would be 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, and the extras $1\frac{1}{8}$, $1\frac{3}{8}$, $1\frac{5}{8}$, $1\frac{7}{8}$, having respectively the same pitches as 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$. Continuing, the standard sizes would run 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, 5, 6, 7, 8, and extra sizes could be added if desired. In this way there would be 25 standard sizes between $\frac{1}{8}$ in. and 8 in. inclusive with 24 extra sizes interpolated. The standard sizes would naturally fall into general use by reason of their simpler bases 4, 5, 6, 7, as compared with 9, 11, 13, 15, and the extra sizes would always be in readiness for renewal or repairs.

E. Howard Reed took up the causes operating for and against the general acceptance of the A. S. M. E. standard. The manufacturers have welcomed the definition of sizes and limits, the reduction of the number of pitches and the liberal allowance in setting limits of variation. Against it is mainly the existence of some previously existing standards which are held to by large users of machine screws. Foremost among these is the Pratt and Whitney standard which is used by the electrical industry. It is, however, Mr. Reed's experience that changes in the A. S. M. E. standard could be brought about more easily than seems to be imagined by those using other standards. This could be done for sizes where a noticeable variation occurred, by changing the size directly from one to the other, arranging as near as possible to use up taps, screws and parts to the existing standard before starting on that of the A. S. M. E., or, by comparing each standard, size for size, and gradually working the existing standard over by increasing or decreasing by small increments the limits of that size untill the A. S. M. E. limits were reached.

As to the manufacture of screw threads to the A. S. M. E. standard, the most important point is the placing of emphasis on the pitch diameter instead of on the outside diameter. This also is the principal point of difference between the cut thread and the rolled thread: while in the cut thread the outside diameter is determined by the outside diameter of the stock chosen, in the rolled thread there is also the shape of the die, the variation of the diameter of the blank and the adjustment of the rolling dies, all of these being factors in determining the outside diameter of the finished screw.

Once adjusted, the pitch diameter of screws produced by the thread roller remains constant during the life of the dies, while the outside diameter varies with the size blank on which the thread is rolled. This being the case an examination of the limits cannot fail to show how well suited the A. S. M. E. standard is for the production of rolled thread.

With regard to machine screw nuts, the application of the A. S. M. E. standard emphasizes a different set of conditions. Trade through long usage has been accustomed to a set of very coarse pitches: e. g., with $\frac{1}{2}$ in. diameter screws, 10-24 would be proportional to $\frac{1}{2}$-9, and 4-36 proportional to $\frac{1}{2}$-8. When you consider tapping $\frac{1}{2}$-8 or 9 and making full threads in steel nuts, you have the problem of manufacturing machine screw nuts. Even though these are proportionally thinner than fractional sizes, it is commercially impossible to tap a full thread, so that, from a manufacturer's point, the tap drill table in the A. S. standard will not give a working basis for punching or drilling nuts. Machine screw nuts with only half thread are generally speaking acceptable to the trade, and when they are apt to be used with screws of various standards it is possibly better that no attempt is made to tap full threads.

Luther D. Burlingame. For many years and from many directions there has been a call for an additional screw thread standard finer than the U. S. standard thread, not to replace the U. S. standard but to provide for other needs.

In 1885 Maj. William R. King read a paper before the American Institute of Mining Engineers on the subject of screw threads in which he took the ground that the U. S. standard thread is of too coarse a pitch for certain classes of work, claiming that the threaded bolt made according to that standard is weakened more than is necessary, and proposing a standard having an increased number of threads, thereby reducing the depth of thread.

In 1887 John L. Gill, Jr., read a paper before the Franklin Institute also criticizing the U. S. standard thread for certain classes of work and advocating a thread which would not cut so deep. He says, "To have a thread suitable for all kinds of work is not practicable," and for this reason he favors the adoption of an additional standard.

At the Boston meeting of The American Society of Mechanical Engineers in 1902, Charles C. Tyler presented a paper on "A Proposed Standard for Machine Screw Thread Sizes." This led to an extended discussion in which a number of standards were proposed all calling for finer threads than would be obtained by using the U. S. standard formula.

At the meeting of the Society in December 1902, Charles T. Porter read a paper entitled Finer Screw Threads. He said, "I have for several years felt a growing conviction that the pitches of our machine screw threads are far too coarse and ought to be changed. They reduce the area of the bolt unnecessarily. The Sellers (U. S. standard) thread made a considerable gain in this respect, but in the larger bolts the reduction of area is still two or three times as much as it needs to be. Again, the inclination of the thread permits the nut to be jarred loose easily. For these two reasons threads of a much finer pitch seem to be called for."

In 1902 a committee on screw threads, consisting of thirty members, was appointed in Great Britain representing the Institutions of Civil Engineers, Mechanical Engineers, Naval Architects, Electrical Engineers and the Iron and Steel Institution besides a number of other interests, and after making careful inquiries and holding extended conferences, the committee brought in a report advocating the addition of a fine standard for screw threads to be used in addition to the Whitworth screw thread standard. This to be called The British Standard Fine Screw Thread. In making the report the committee said, "Inquiries have, however, elicited a practically unanimous expression of opinions that the existing Whitworth series of pitches for screws from $\frac{1}{4}$ in. to 6 in. in diameter inclusive do not fully satisfy all requirements, and that where the screw thread is subjected to shock and vibration or extra strength is required in the core of a screw of given diameter, finer pitches are desirable.

"These facts led the committee to draw up the recommendation and table of standard sizes contained in this report."

In April 1906 the Association of Licensed Automobile Manufac-

turers of America adopted a standard having radically finer threads than the U. S. standard. In connection with their report the following statement is made. "During recent years manufacturers of fine machinery have found from experience that for a large portion of their work the U. S. standards for pitch of threads have been too coarse. . . . . In order to secure satisfactory construction special fine pitch screw threads have had to be made. The number and variety of these special threads have finally become such that great confusion, inconvenience and expense have been caused."

During the years 1905 to 1907 the matter of a standard for the small size screws was agitated by the Society and a committee, appointed by that body, formulated a standard which was adopted and which provides for fine threaded screws within the range from about $\frac{1}{16}$ in. diameter to $\frac{7}{16}$ in. diameter.

In June 1908 a report was presented at the annual convention of the American Railway Master Mechanics Association at Atlantic City, N. J., proposing a standard thread finer than the U. S. standard for special thin castle nuts. The report says, "There are, however, a number of large-sized nuts used on the locomotive, the thickness of which, on account of clearances, does not permit the use of the standard number of U. S. threads, and with the coarser threads there is liability of their working loose. To take care of such cases we have shown on plate 4 the number of threads per inch to be used on this class of nuts which will be known hereafter as the 'special thin castle nut.' These threads are finer than the U. S. standard and are practically the same as the threads often used for bolts in ship building construction where they are tapped into thin plates or are employed in places where thin nuts must be used."

During the same month that this matter was considered by the American Railway Master Mechanics Association, a paper was presented at the Detroit meeting of the Society by Amasa Trowbridge, entitled A Comparison of Screw Thread Standards in which he suggested the combining of the Society and the U. S. standards by making a new connecting link giving a finer thread than would be obtained by the U. S. standard for the $\frac{1}{4}$ in. to $\frac{7}{16}$ in. screw threads. After giving some study to Mr. Trowbridge's paper, it seemed to the writer that it was an opportune time to present for the consideration of the Society an intermediate standard to cover not only the need pointed out by Mr. Trowbridge but to meet the whole situation by extending the A. S. M. E. standard and producing

an intermediate standard which could be used in connection with the U. S. and with the A. L. A. M. standards, not with the idea of displacing either of these, but in order that the varying needs might all be covered with authorized and well established standards and thus reduce to a minimum the need of using special threads. With this thought in view, the writer worked out a formula and presented it at the Detroit meeting as a discussion of Mr. Trowbridge's paper. This formula gives threads practically coinciding with the adopted A. S. M. E. standard within the range for which that standard provides, and above that point is intermediate between the U. S. standard and the very fine pitches of the A. L. A. M. standard, thus meeting the needs of general machine work which would be better covered by a standard coming between these two extremes. It also provides for screws down to the smallest watch screws 0.01 in. in diameter, and also up to screws 6 in. in diameter, and gives results closely approximating the pitches used for screws by many leading manufacturers at the present time.

The fact that a thorough study of the situation by a competent committee in Great Britain has shown the existence of such a need gives confidence in urging that a similar need should be provided for in this country and it is hoped that steps may be taken to bring this about.

A. A. FULLER then read a discussion on the relation between angular diameter and lead.

By error in angular diameter, he said, is meant the difference between the actual and theoretical diameters as measured by a V-thread micrometer having a conical point on the measuring screw, and a V-anvil at the opposite end of the micrometer. By error in lead is meant the difference between the actual and theoretical measurements of two threads supposed to be 1 in. apart.

The desirability of uniform tapped holes is so apparent as to need no argument. With uniform tapped holes once established, a variation in the size of the screws, studs or bolts to fit the holes with any degree of tightness desired is a matter quite readily controlled. This analysis intends to cover only the most common uses of tapped holes, i. e., those that are intended to receive screws, studs or bolts for binding or holding together the parts of a machine or mechanism. These holes should be so nearly alike that for a given length or depth of hole a standard screw plug gage will fit in all the holes within an allowable tolerance in tightness.

Errors in angular diameter are easily comprehended and measured. An error of this kind produces the same effect as an error in the

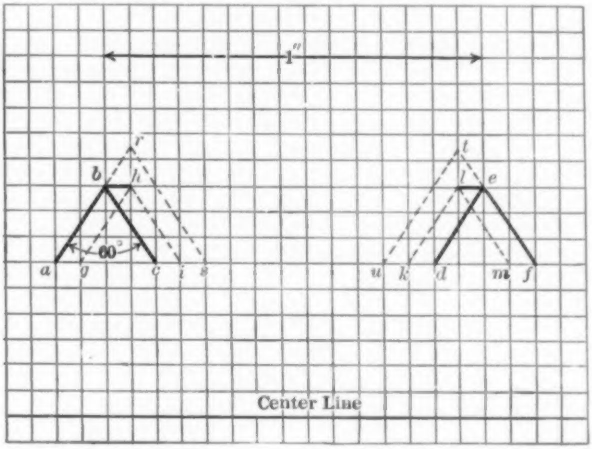


FIG. 16 HOLE TAPPED LARGE TO COMPENSATE FOR ERROR IN LEAD

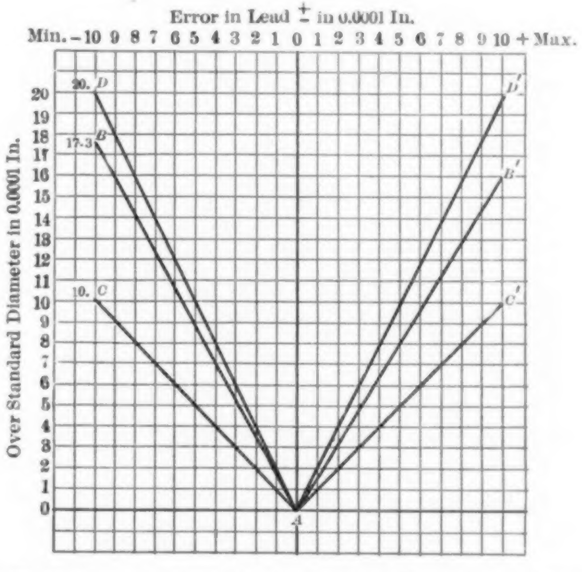


FIG. 17 RELATION BETWEEN DIAMETER AND ERROR IN LEAD FOR TAPS FOR HOLES ⅝ IN., 1 IN. AND 1¼ IN.

size of a reamed hole, i. e., it causes a variation in the tightness of the fit between the hole and the male member intended to fit the

hole. Within practical limits it is independent of the length of the hole, and the amount of variation allowable is inversely as the accuracy required.

Errors in lead are not so easily measured except by special machines constructed for this purpose, such as one made by the Brown

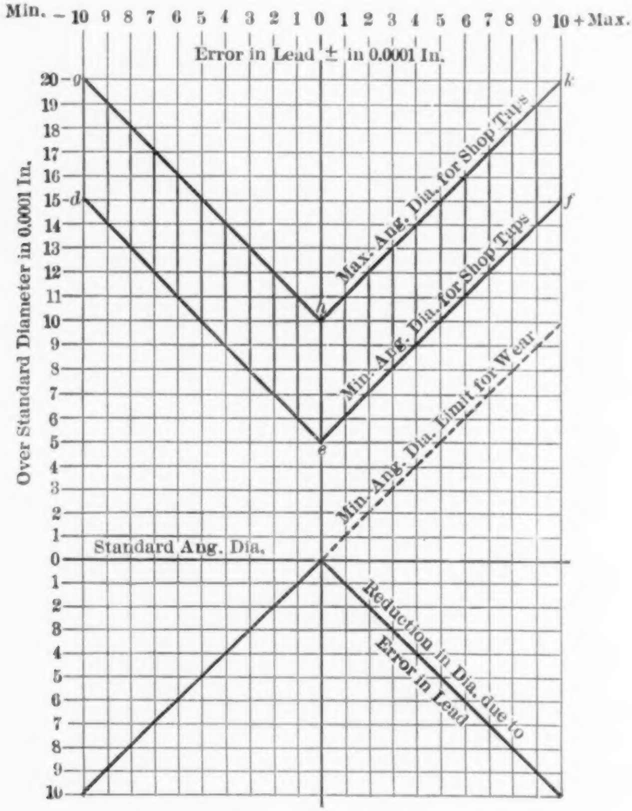


FIG. 18 ZONE OF TOLERANCE FOR TAPS CLASS NO. 1 FOR THREADS 5/8 IN. LONG OR UNDER

& Sharpe Manufacturing Company. The effect of an error in lead is not direct. A plus error and minus error both produce the same effect as far as the fit of our standard plug is concerned, the practical effect of any error being a reduction in the size of the tapped hole, i. e., our standard screw plug will not enter the hole the required depth. Moreover, the amount of reduction is dependent on the

depth of the hole tapped. For a 60 deg. thread and a hole 1 in. deep it has a greater proportional influence on the diameter of the hole than the angular diameter, 0.058 in. error in lead equalling 0.100 in. error in angular diameter. The allowable variation in lead is dependent on the depth of the hole. For a short hole more error is allowable than a deep hole; but as it is more difficult to tap a long hole with less error than a short hole, in practice it is better to adhere to an allowable error in lead per inch and to compensate for that error by varying the angular diameter.

Referring to Fig. 16, let *abc* and *def* represent the theoretical position of two spaces one inch apart cut by a tap with correct lead. Let *ghi* and *klm* represent two actual spaces cut by a similar tap with an error in lead equal to $bh+le$. Then the stock *abhg* and *lmef* would interfere with the entrance of a standard screw plug. In order to remove this stock with a tap having the same error in lead, it would be necessary to increase its radius by the amount *rh*. The new spaces then cut would be represented by *ars* and *utf*, and the standard plug would bear along the surface *ar* as far as *b* and along the surface *ft* as far as *e*. Then

$$rh = \text{increase in radius}$$
$$2rh = \text{increase in diameter}$$
$$bh = le$$
$$bh + le = 2bh = \text{error in lead}$$
$$\frac{bh}{rh} = \text{tang. } 30 \text{ deg.} = 0.577, \text{ say } 0.58$$
$$bh = rh \text{ tang. } 30 \text{ deg.}$$
$$bh = 0.58\ rh, \text{ or } 2rh = \frac{2bh}{0.58}$$
$$\text{Increase in diameter} = \frac{\textit{error in lead}}{0.58}$$

In Fig. 17 the straight lines BA and $B'A$ represent this relationship.

If the depth of the hole is less than 1 in. it is necessary only to correct the diameter proportionally. On account of the lack of bearing, an error in lead is more objectionable than an error in angular diameter. If we assume an allowable tolerance of lead of +0.001 in. to the inch, then for a hole 0.58 in. deep an increase of 0.001 in. in diameter would just compensate for this error. The straight lines CA and $C'A$ would represent the relation between

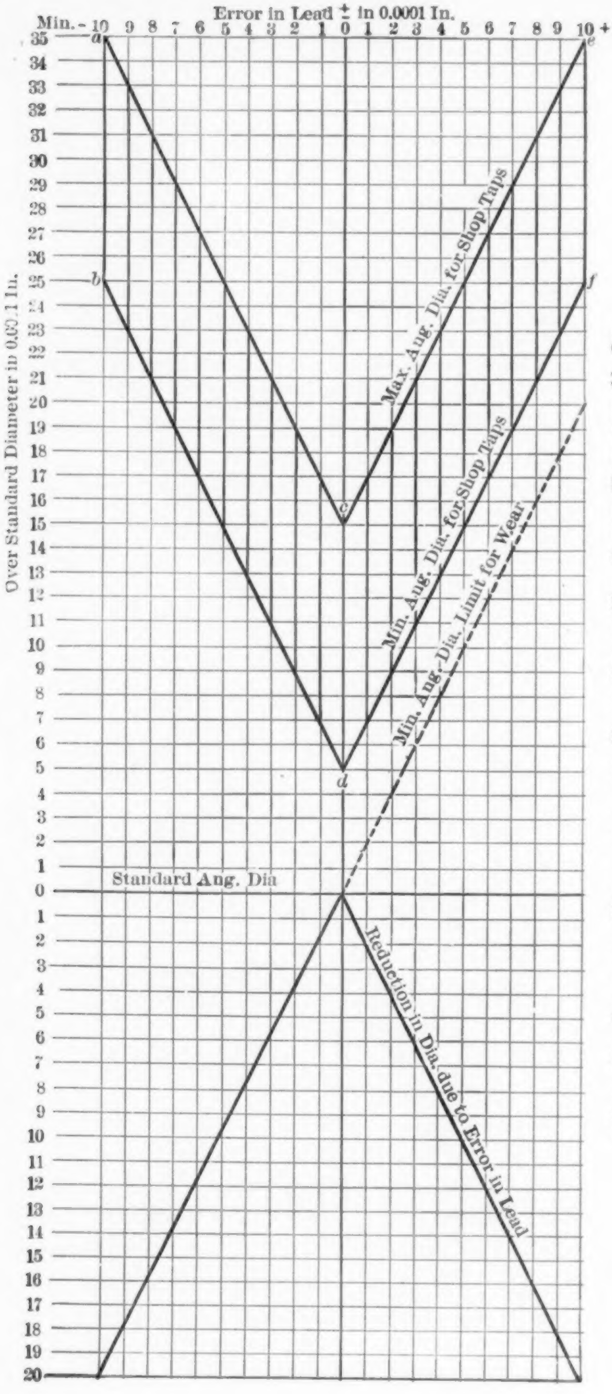


FIG. 19 ZONE OF TOLERANCE FOR TAPS CLASS NO. 2 FOR THREADS $\frac{11}{16}$ IN. TO $1\frac{1}{4}$ IN. LONG

error in lead and increase in diameter necessary to keep the hole standard for a depth of 0.58 in. In practice it is desirable to have the taps slightly larger than standard. We can, therefore, move this line bodily upward a distance corresponding to 0.0005 in. and assume it to represent the relation between the error in lead and the *minimum* allowable angular diameter as shown in Fig. 18 by line *def*. Now, if we establish a tolerance in diameter of 0.0005 in. above this we have the line *ghk*, representing the relation between error in lead and maximum allowable angular diameter. The shaded area between these two lines represents the zone of allowable tolerance in lead and angular diameter that will produce tapped holes 0.58 deep within a variation of 0.0005 in. for practical running diameter. Without introducing any very great error, we may allow this zone to stand for all holes under $\frac{5}{8}$ in. in depth. As the majority of holes on automobile work are less than this depth, averaging, say, $\frac{3}{8}$ in. to $\frac{5}{8}$ in., this zone was adopted as a basis for inspecting all taps for holes under $\frac{5}{8}$ in. deep. Commercial taps were subjected to inspection to meet these requirements, and taps passing inspection were designated as Class No. 1 (Fig. 18).

By similar reasoning, the increase in angular diameter to compensate for error in lead for a hole *over* 1 in. in length must be greater than that for one 1 in. long, and for a hole 1.16 in. deep, an increase of 0.002 in. in angular diameter would have to be made to compensate for an error in lead equal to 0.001 in. to the inch as before. Assuming this as a standard, then in Fig. 17 the straight lines *DA* and *D′A* would represent the relation between error in lead and increase in angular diameter to exactly compensate for it on all holes 1.16 in. deep. Raising this line 0.0005 in. for a minimum angular diameter limit and establishing a tolerance of 0.001 in., we have in Fig. 19 a zone *abcdef* representing inspection limits applying to taps to be used on holes $\frac{11}{16}$ in. to $1\frac{1}{4}$ in. deep without introducing serious errors. Taps passing this inspection are designated as Class No. 2. Usually the diameter of the taps increases with the depth of the hole. Class No. 2 usually covers larger taps than Class No. 1. In like manner other classes could be established for deeper holes, or other classes for the same depth of holes with larger or smaller tolerances could be added. The only practical objection would be the difficulty of keeping them classified in the tool room and keeping track of them in the shop.

THE MECHANICAL HANDLING OF FREIGHT

By Samuel B. Fowler, Published in The Journal for January 1911

ABSTRACT OF PAPER

Lack of adequate terminal facilities, increase of net income and lower freight rates present problems the solutions of which are vital to the transportation company, shipper and consignee alike. Additional facilities are difficult to obtain, since there is usually no available land adjacent to the terminal or it is held at a prohibitive price. The capacity of present terminals can be increased by handling larger unit loads and moving them at greater speed, as well as by increasing the floor area by the use of freight sheds of more than one story. This is made possible by the substitution of mechanical devices for manual labor and hand trucks.

The terminal handling cost is a large item in freight charges. Mechanical handling methods will reduce the total transportation cost sufficiently to permit of a material gain in income, a decrease in rates, or possibly both.

The use of machinery will also bring about a new type of terminals and a revolution in present terminal methods, making possible other important economies. These economies are possible with team freight as well as l.c.l. freight, and with water-borne traffic as well as rail-borne traffic.

The problems thus presented should be worked out with a mind free from the bias caused by long familiarity with present practices.

DISCUSSION

DISCUSSION AT NEW YORK

L. De G. Moss[1]. Mr. Fowler's statement in Par. 20 is of great importance. At many important terminals, it is all but impossible to enlarge the area as a means to lessen congestion and delay, since a greater interest account, which is ultimately paid by the public, would result.

In Par. 10, Mr. Fowler gives the actual cost of rail-freight transportation, including operating expenses and interest on permanent way and rolling stock, as 3 mills per ton-mile. The revenue per ton-mile which is the cost to the users and paid for by them might preferably be given. This average cost per ton-mile in the United States

[1] Cons. Engr., 248 W. 131st St., New York.

is about 7.6 mills. The rate was 1 cent in 1888, with earnings of about $2300 per mile of track. Since 1898, the revenue has fluctuated between 0.763 cent and 0.724 cent and the earnings per track-mile have risen to over $3900. The length of haul is increasing, a potent factor in the reduction of rates. The ton-mile standard must be used with caution. Some Americans say with mistaken pride that freight carriage in England costs a little over 2 cents per ton-mile, ignoring the fact that the average haul here is about 5.5 times as long as in England. The comparison for equal hauls is not in our favor. Coal, which is readily loaded and unloaded, and moved in large quantities in cars which have a very low ratio of non-paying load, can be operated for 3 to 5 mills per ton-mile. Larger locomotives and trains, better cars and road bed, are all tending to increased earnings per mile of track, and to a reduction in the cost per ton-mile.

Turning to water-borne freight, coal is carried on the Great Lakes for about 1 mill per ton-mile under exceptionally favorable conditions, such as a specially designed hold which permits very rapid unloading, large unit cargoes, and the fact that the east-bound traffic consists mainly of iron ore and grain, while on the westward trip coal is usually carried. On the canals of New York State, which have not yet received the full benefit of the enlarged waterways and larger unit carriers, the cost is about one-third that of railway transportation. Coal is taken on the Mississippi River from Cairo to New Orleans, for 0.5 mill per ton-mile. On long ocean voyages, say from London to Bombay, 10,754 nautical miles, the cost is about 0.6 mill per ton-mile.

Some American railways earn 1 cent per ton-mile; others fall to 0.5 cent, and find it difficult to operate with this slender revenue. Referring to Par. 11 of Mr. Fowler's paper, Mr. Byers, chief engineer of the Missouri Pacific Railway, analyzed the cost of terminal freight handling for 30 stations, as follows:

Labor and car shifting	$0.415
Fixed charges and amortization	0.286
	0.701

Many statistics fail to contain the legitimate fixed charges.

A common defect in existing terminals is that it is not possible in most cases to deliver or receive direct to or from wagons and teams. Team freight costs 4 to 8 cents per ton for handling, depending on the size, shape and weight of the packages. If the same materials are landed on the station platform and moved through the station to the car, the handling charge will rise to from 30 to 50 cents per ton.

There are two great difficulties to be overcome when mechanical transporters are used. Such devices must carry good sized loads to be economical. Therefore a skip or apron is needed for much of the freight received in light packages, and there must be a safe, clear space between cars, into which this skip can be lowered so as not to injure the sides of the cars.

If the box-car roof had a large hatch through which loads could be handled, the problem would be almost as easy as the unloading of flat cars if it were not for the fact that it would sometimes be necessary to unload cars under cover to exclude rain and snow from certain kinds of freight. The easy conditions can never be obtained that are met with in handling loose materials in gondola cars, which may be emptied from above or below, or tipped over by a dumper.

In some cases tracks could be arranged with island platforms, upon which packages could be delivered in or out, connecting the platforms by overhead cranes and telphers. Great skill would be demanded in their operation to avoid confusion between incoming, outbound, and transfer freight. These island platforms would also need a central depot where freight could be delivered, checked, weighed, invoiced, receipted for, and classified, before being sent out to one of the island platforms for storing. If the tracks and cars could be arranged to receive team freight direct, that would excel almost any mechanical device, except for very heavy loads, as long as box cars are used. These methods require expansion of area, which in turn means financial difficulties.

An obvious advantage to be gained by the use of gantrys, cranes and telphers, is in elevating a load to upper floors and in tiering packages. In England we find cranes of all types, operated by hydraulic or electric power, installed so as to serve practically any part of an important terminal. There geographical conditions make the typical terminal one in which both water and rail transportation enter; and a steamship dock, gantry cranes, railway tracks, teaming space, more railway tracks, platforms and freight sheds are found abutting on a driveway. The hydraulic crane, although safe and easily controlled, is giving way to the electric type, which is cheaper to install and to operate.

For marine terminals with mechanical equipment, Hamburg is the city to study. One dock alone, the Kuhwaeder, has over 130 cranes, the Municipal Dock about 100 cranes, the Free Haven, about 600. There are in all, about 1000 cranes, a few of which can lift 75 tons.

In the port of New York, aside from some good floating cranes, there

is only one pier equipped with cargo cranes, the Greenville pier of the Pennsylvania Railroad which has three C. W. Hunt unloaders, each handling 10 tons, with a large overload capacity.

Mr. Fowler points out in Par. 78 that comparing the cost of freight handling in San Francisco without machinery and Hamburg with its superb machinery, the difference in cost is but 10 cents per ton in favor of the latter. That looks small, but the multiplier is large. It enabled the city of Bremen to expend about $30,000,000 for harbor improvements and machinery, which was returned fully by the difference between the freight charges and cost of operation, and the increased traffic. In some cases, greater speed of loading steamers will not be of much importance, since the careful stowing of cargo below limits that, as well as the fact that as soon as many steamers are docked the "black watch" is engaged day and night, often with outside aid, in overhauling, adjusting and repairing.

F. B. Freeman.[1] In Par. 5 Mr. Fowler states that the inefficiency of the country's transportation service is strongly emphasized and emphatically stated to be due to inadequate terminal facilities. I believe that all the railroads will reply that it is a matter which is being rapidly corrected. Some years ago, when the great increase in traffic developed, the majority of the railroads had insufficient main tracks to move freight properly from one point to another. Main tracks therefore were the first point of attack, as is was not possible to obtain sufficient money to do everything necessary at once.

Now that the main tracks have been made adequate for the transportation of freight, the railroads are working on the development of their terminals and making them of sufficient capacity to handle all business offered them, with as little delay as possible. I think it safe to say that within a very few years this difficulty will be overcome just as completely as the inadequacy of the main tracks has been overcome. The matter is not going to be neglected and the railroads will meet all conditions just as rapidly as money can be obtained in order to carry out the improvements.

In Par. 6 Mr. Fowler states that the essential factor in the transportation costs is not that of handling the goods, but the expense of handling at terminal stations. In this connection it must be borne in mind that the excessive cost of handling freight at terminal stations, is due to the rehandling. The consignees practically all over the country have four days in which to take freight away from the

[1] Ch. Engr., Boston & Albany R. R., South Sta., Boston, Mass.

freight house. This means that each freight house has to be practically four times as large as is necessary for the handling of the daily business at the station. It also must have some additional area in which to handle freight which is not taken away, even within the four-day limit. This necessitates the rehandling of the freight in the house in order to deliver it to the consignee who arrives first. In Par. 7 he mentions the congestion of terminals, which is in a great number of instances due to the same difficulty, that all the consignees do not take away their freight promptly on its arrival. I believe that the cost of handling freight at outbound houses is not excessive for the reason that it is handled on the day that it arrives, i.e., the outbound freight house is practically empty every night.

In Par. 15 he states that the solution is the design of an entirely new system of terminal, adapted to the use of machinery. It should be borne in mind that all the old terminals which would be wiped out will still be a burden on the railroads, as they have been covered by bond issues, the interest on which would have to be met. This would all have to be borne by the freight charges in some form or other.

In Par. 23, item *b*, he speaks of tiering the packages in the freight house. To anybody who has studied the question of freight handling, it would be perfectly evident that tiering of packages in the freight house, no matter how accomplished, will lead to additional handling costs for the reason that in the majority of cases the lots to any one consignee are small. Should the goods be so tiered the probabilities are that the consignee whose lot is at the bottom of the pile will be the first to call for his goods. Supposing for instance, that in one bay of a house, there were piled 100 tons of freight. It is quite possible that there might be 20 or more consignees for this 100 tons of freight who would call for their particular consignments any time during the four days after they had arrived and had been stacked. This would necessitate, in all probability the moving of all the freight, in order to give each consignee his portion of it.

In this connection the only possible solution that there appears to be to the question at present, is to furnish sufficient floor space practically to pile the freight in consignment lots, so that it may be reached with the least possible amount of rehandling, other than that necessary for delivery at the moment.

In Par. 25 Mr. Fowler makes a statement that a single transporting machine, operated by one man, should be able to replace at least 16 truckers. In this connection the hand truck is practically a perfect machine for the purpose. With one man in the freight car, the man

handling the truck can pick up and take away packages of very considerable bulk and weight. With the mechanical operation of carrying increased loads which Mr. Fowler mentions, it would be necessary to put additional men in the freight car in order to move the material from the freight car upon the mechanical carrying device, whatever that might be. Where one man could move a package with the hand truck, it would probably take three or four men to move this same package from the freight car to the mechanical carrier, so that it would appear that the men taken off the truck would be simply turned into the freight cars, and no saving in cost in that connection would be made. The same line of reasoning would apply to the handling of goods in the freight house.

Referring to Fig. 1, Mr. Fowler makes the statement that considerable area would be saved with such a mechanical arrangement. Assuming for a moment that Fig. 1 has 11 tracks holding 10 cars each, and an average load of 20 tons per car, 2200 tons of freight could be delivered. It would seem that in any freight house the minimum space necessary to handle 1 ton of freight is about 25 sq. ft. so that therefore the freight house would require 55,000 sq. ft. to handle these 2200 tons of freight. Figuring on the basis of the length of tracks, it would be possible to make the house 600 ft. long, and it would therefore be necessary to have it 91 ft. wide. The availability of both sides of the house for trucking would give 1200 L. F. of trucking space. A layout consisting of tracks, intertrack platforms 25 ft. wide, driveway alongside the house and house delivery, would require about 250,000 sq. ft. On the basis of the present system a business of 2200 tons would require three tracks holding 37 cars each and a house 1500 ft. long by 50 ft. wide. This would give 75,000 sq. ft. for handling freight. It would also give 1500 L. F. for team frontage and the total area required would be about 150,000 sq. ft., or about 100,000 sq. ft. less property to do the same business than that which the mechanical layout would take, with 300 L. F. more space for teams.

It does not appear that more than one carrier could be worked to any advantage on each intertrack platform, so that if all of these tracks had to be worked together, there would be six mechanical travelers loading and moving on the trolley lines. It is fair to assume that at times all of these carriers would get into the freight house section at the same time and it would be inevitable that considerable delay would be caused to the moving of the travelers, so that the men in the freight house would be standing idle, as well as the men in the cars. With the present method of handling by trucks it can be so

arranged that there is no delay; it is a continuous movement, and with good management every minute of every man's time can be fully occupied.

In Par. 63, Mr. Fowler states that the freight-handling capacity of a given floor space can be doubled, if the goods can be moved twice as fast, from it or to it. This cannot possibly be done, since the freight has the right to lay on the floor for four days and it is absolutely out of the power of the railroad companies to expedite its movement. It has to stay there until the consignee calls for it. It is a fact that most of the congestion today at large terminal freight houses is due to the inability to get teams up to the delivery platforms. The mechanical arrangements would not appear to offer a solution to this feature unless there were an additional system of mechanical handling arrangements which would carry the freight from the freight house to the specially built delivery platforms. By constructing such platforms, sufficient accommodation could be made for backing up teams, but there would then be the delay in transporting the freight a considerably longer distance to deliver it to the wagons. There would be an additional burden of interest on capital cost for these loading platforms, which would be available for no other purpose. The interest on such investment would have to be borne by the freight.

In Par. 65 Mr. Fowler states that in many cases it would be possible to have packages piled on flatboards to be instantly removed from the teams by transporting machines. At large terminal freight houses, the number of times that this would happen would be negligible.

In a general consideration of this subject, it should be noted that the railroad companies are in a peculiar position in the matter of freight handling. They have to manage all classes of freight, all sorts and sizes of packages, under all kinds of conditions. In one car there might be a package of very small bulk that weighs a ton, and in the same car a package of immense bulk that weighs very little. These conditions seem to be met more fully by the use of the hand truck than by any other device yet brought to the attention of the railroad companies.

The various industries that are handling practically uniform packages, and which have an opportunity to grade them, do not appear to have adopted a mechanical system to any great extent. This is the first field for development of the mechanical handling of freight, and in view of the fact that the industries are not adopting this method where they have the incentive to do so and un-

doubtedly the most probable field for its success, it does not seem to me that much progress can be made in the handling of freight at railroad terminals.

J. P. SNOW.[1] While I do not want to be understood as discouraging the mechanical handling of freight, I hesitate to approve the scheme described by the author as applicable to the general problem of handling L. C. L. freight. It is admitted that the terminal costs far exceed the transportation costs even for long hauls, but these costs are not all by any means between the wagons and the cars. The maintenance and operation of the yard and switching organization forms a large item.

The essence of the scheme proposed by the author is to introduce a carrying system between the wagons and the cars. Goods must be unloaded from the wagon, loaded on the carrier, weighed either before or after this loading, records made for billing, unloaded from the carrier after their journey and stowed in the car. As against trucking from the wagon over a scale and direct to the car, the truck leaving the package practically stowed, we have what amounts to an auxiliary transportation system with its two terminals, in lieu of the one simple handling by means of trucks.

The objection raised by the author to spotting cars is not of serious moment and is yearly becoming of less account for the reason that our cars are now being built to M. C. B. standard lengths. The days of freak cars are passing. The advantage of loading cars without moving them from where they are unloaded, as suggested by the author, is an ideal method that cannot be used until the millennium of single ownership is reached; so that cars need not be rushed back to their home road as soon as released from load. Even in passenger service, when the cars are of single ownership, it is not possible to make nearly so many train turns as it might seem. At a large terminal with 500 trains per day, only about 50 can be so turned without reshifting cars.

The true field of a mechanical handling device is where the material and movement is uniform and constant, as in a manufactory or where the distance of transport is considerable. L. C. L. freight, either coming or going, is not of this class under ordinary conditions. At a wharf or pier-head, where the tracks are at right angles to the vessel's berth it is difficult to reach cars enough by ordinary trucking

[1] Ch. Engr., Boston & Maine R. R., North Sta., Boston, Mass.

to receive a full boat-load; and here a telpher system may be used to advantage. It should carry the goods far enough into the yard to reach a point where cars can be readily shifted as wanted. More or less height of hoist is immaterial in a good telpher installation; hence for discharging vessels of various kinds it can raise or lower through hatches as well as transport to a convenient car platform, and its usefulness cannot be denied.

The author's suggestion that railroads deliver goods to consignees is well worth attention by our managers. An outfit of motor vans would seem to supplement properly the present somewhat incomplete equipment of railroads as common carriers. One serious trouble at freight terminals is the practice of consignees in refusing or neglecting to remove their goods promptly on arrival. If railroads did the forwarding, they could clear the houses much more promptly. This argument applies to team or bulk freight as well as to house freight.

J. H. Norris. During the past 15 years I have watched with interest the efforts of the Bush Terminal Company, Brooklyn, to handle freight. The property covers half a mile of water front and nearly a square mile of warehouses, and the proposition of handling the freight as it comes from the foreign and coastwise ships does not to my mind lend itself to the telpher system as described by Mr. Fowler.

The goods from ships are usually hoisted upon the dock and are piled according to their marks in lots for the examination and passing of the custom inspectors. These goods have to be sampled and weighed by the government and are usually re-weighed by the city weighers in the interests of the importers. Under these arrangements the requirements of freight handling are rather severe.

In the first place, a number of the goods are permitted and delivered direct to the importers' trucks on the dock; other goods are shipped in bond direct in cars or upon lighters; while other goods are taken to the warehouses and stored until wanted.

Fig. 3 shows the seven docks, each nearly 1400 ft. long, the warehouses and the railroad terminal. From this it will be plainly evident that a telpher system capable of handling freight would be so complicated and cumbersome as absolutely to prohibit its use.

After the incoming freight has been properly passed by the custom authorities and if it is to go into warehouses, the method of handling on these docks is to load it on small low trucks that have been drawn up to within a short time by horses or mules (Fig. 4), and to cart it to the warehouse to which it is assigned.

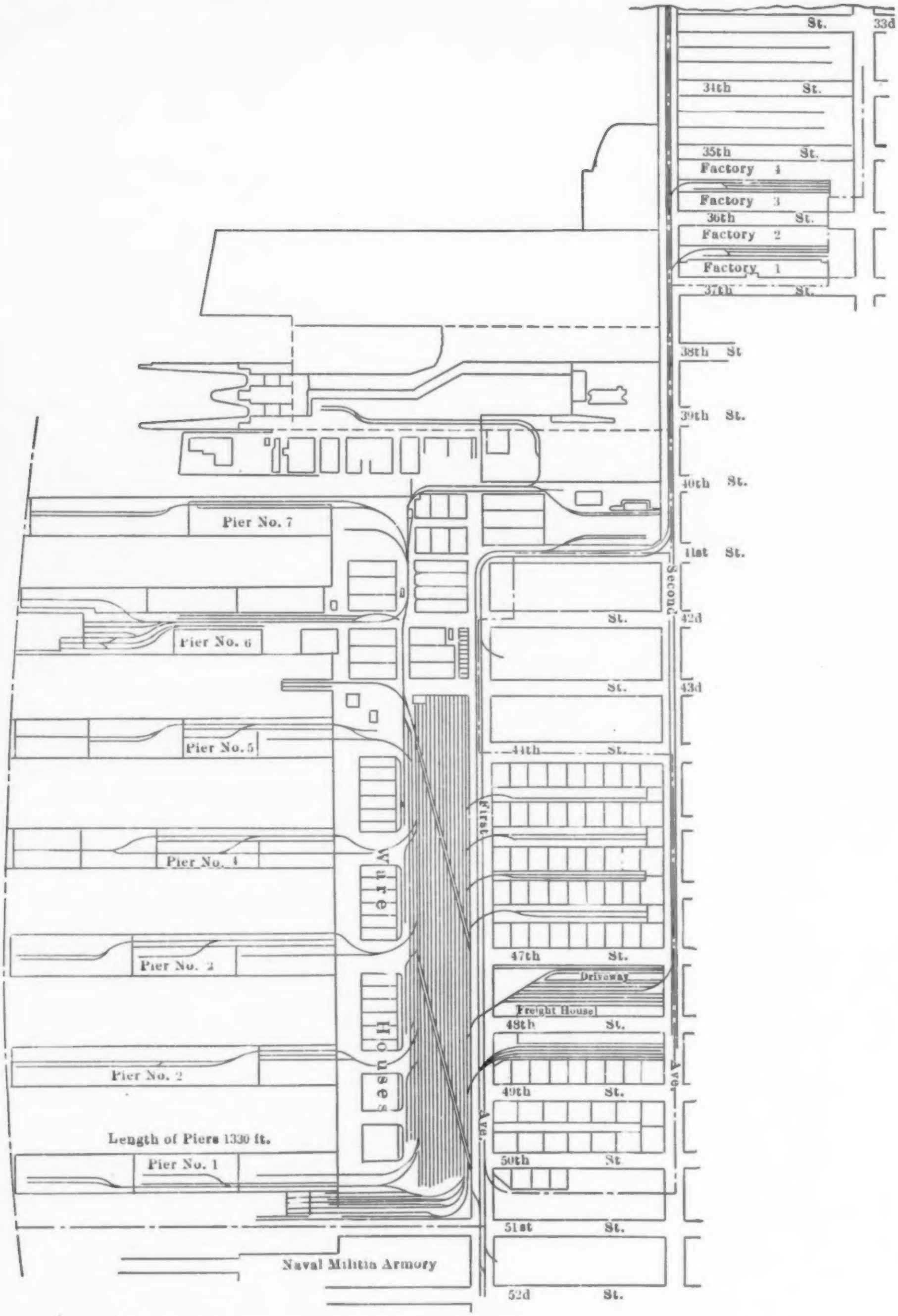


FIG. 3 ARRANGEMENT OF THE BUSH TERMINAL, BROOKLYN, N. Y.

The warehouses were originally equipped with elevators large enough to hoist these trucks to the floor desired, and a horse drew it to the proper section where it was tiered. Within the last year, however, they have adopted a storage battery truck (Fig. 5) which, while carrying a small load itself, can draw three of the other trucks and haul them to the desired position. Instead of elevators, electric hoists are now placed on the ground with ropes leading to blocks over the doorways in the warehouses and the goods raised and lowered in this manner. In addition to these fixed hoists, a number of portable

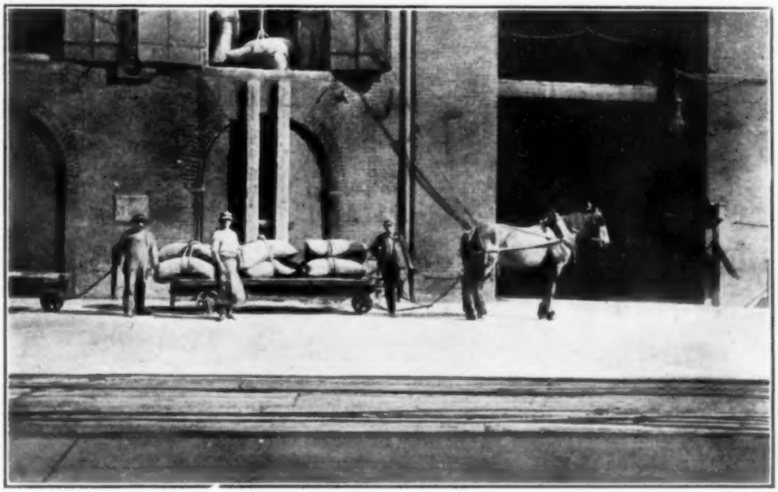


Fig. 4 Horse-Drawn Trucks in Use a Short Time Ago at the Bush Terminal

electric ones which can be hauled anywhere around the docks or warehouses are in operation.

Beside the general merchandise coming in on ships, large quantities of cotton, coffee and sugar are handled, and stored in the six-story warehouses along the river front. The warehouses in which the cotton is stored are one-story buildings divided into a number of sections by fire walls and protected by sprinklers. When the bales are received at the warehouses, they are tiered by electric hoists, the largest amount of storage capacity for a given amount of space being obtained in this way. Each of the warehouses has a siding in front of the door so that goods received by railroad can be placed opposite the warehouse in which they are to be stored, and handled with the least possible amount of labor.

As large a proportion of the outgoing freight as can be brought to the side of the steamer in lighters is so handled in order to leave the docks free for inbound freight. A great deal of outgoing freight however, comes in carload lots or in wagons and trucks and has to be sorted, counted and measured according to the bills of lading, being usually arranged on the dock in positions set aside for its port of destination if the ship is to make more than one landing. It is then moved in the most convenient manner to the side of the steamer so that the derricks can transfer it into the hold. The stevedores along the docks of New York handle freight of various styles and sizes in a

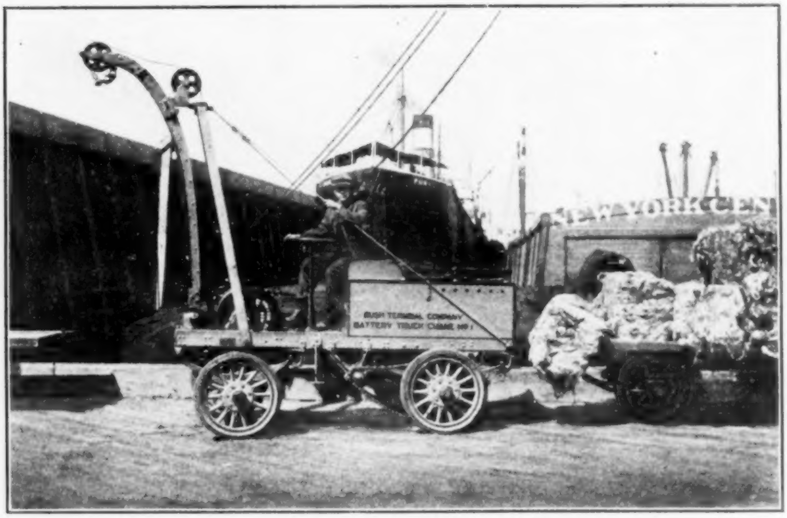


FIG. 5 STORAGE-BATTERY TRUCKS NOW IN USE AT THE BUSH TERMINAL

manner that would surprise the uninitiated, not a single unnecessary movement being made by any of them.

In connection with the docks and warehouses is a terminal railroad with an exceptionally well laid out freight storage yard (Fig. 3). This concern also operates some model loft buildings that are rented for manufacturing and storage purposes. They are equipped with large elevators so that a manufacturer renting space can deliver the goods and receive a bill of lading at the door of his factory, the Terminal Company taking care of shipment, handling it on the elevators and into cars and making deliveries to manufacturers in the same way. This system is the most modern and convenient of which I have any

knowledge, and is similar to the one in use on the English railroads. In handling freight within its own property the Bush Terminal Company employs steam locomotives and where it uses the city streets electric locomotives. It also operates a trucking system for delivering freight in and about the city, consisting of gasolene-motor and horse-drawn trucks. In addition, it operates a marine department, consisting of tugs, car floats, lighters, both of the self-operated type, and barges.

H. McL. Harding.[1] In general it may be said that the handling of freight is an engineering problem depending more upon operation and operative conditions than upon the details of the construction of the conveying and hoisting machinery.

A number of important manufacturing companies are prepared to furnish from specifications, machinery that will fulfil the most exacting conditions of freight-handling service. It is, however, necessary to study and understand just how this machinery is to be combined and operated to perform all movements which are the result of long experience in freight transportation. These operating movements at an outbound station consist in unloading drays, assorting in piles according to consignments and classifications, inspecting, receipting, calling-out, weighing, scribing, routing, conveying, distributing, checking, car-stowage and re-checking. The following principles or rules comprise the essentials to the success of any such installation:

a No rehandling, as exemplified in the operation of tiering.

b To cover areas in the place of lines. The machinery to serve directly the whole floor space.

c Continuous rapidity of movements, as indicated by an unbroken main track and diverse paths.

Rehandling. In Par. 23 Mr. Fowler states, "The cost of tiering by hand is now prohibitive, it being equivalent to rehandling." Rehandling is fatal to any system of mechanical freight handling. This has been recognized by railway engineers and terminal superintendents, as well as by the stevedores themselves, and has, in the past, constituted the principal objection to mechanical methods. Mr. Calvin Tomkins, Commissioner of Docks, New York City, condemns rehandling in the strongest terms. In his report of December 16, 1910, in regard to the problem of transportation, he says: "And to this expense (meaning additional land) would be added the double hand-

[1] Cons. Engr., 20 Broad St., New York.

ling of freight in the terminal building and at the water front. This I believe is a fatal objection to such a plan. It was considered a fatal objection to a proposed tunnel plan which necessitated extra handling."

Some time ago the Pennsylvania Railroad engineeers were considering the installation of freight-handling machinery at one of their new Long Island terminals. A plan of overhead conveying was submitted to and approved by the consulting engineers, but the engineers of the railroad refused to install any overhead system which would require the rehandling of freight. The plan which had been submitted to them consisted of two side parallel main tracks with many cross-over tracks, which were to be placed so near together as to grid-iron closely the overhead space. The necessity of removing the freight from beneath the line after it had been lowered, thereby requiring rehandling, was to these engineers an insuperable objection. Their criticism was not in this case the large cost, but rather the theft, breakage and damage resulting from rehandling, which seemed to them to be of more importance than the additional handling expense.

At a transfer station in Pennsylvania, it was formerly the practice to remove the L. C. L. freight from the cars and place it in a large transfer house some 1200 ft. long by 100 ft. wide. When the cars were emptied, this house was filled with freight, which, after all the cars were unloaded, was redistributed so as to give the maximum load to each car going to different sections of the country. When a new superintendent took charge of the station, he transferred the freight directly from one car to another, without placing it within the transfer house, and effected a saving of $0.40 on every ton of L. C. L. freight handled, as well as reducing the time of transference. These figures were evidenced by comparisons between many monthly reports made before and after these changes were effected. Scarcely a ton of freight could be seen in the building after the change.

Similar examples can be obtained today in almost all important transfer stations. The amount of freight held or stored is generally less than 2 per cent, and this is chiefly due to errors in routing or breakage. Every transfer superintendent refers with pride to his present low percentage of rehandled freight.

Tiering. To tier successfully it is necessary to pile the boxes, bags, barrels and cases to a considerable height in order to utilize to the greatest advantage the space within the transshipment sheds. To give a specific example, a box, say 3 ft. square, is conveyed and

lowered by the hoist of the overhead carrier upon the floor, and next to this in line is placed another box, and so on, directly under the track of the overhead carrier. On top of this row it is possible to lower two or three more boxes, but above this there is a tendency for the freight to topple over. Upon either side of this first row of boxes, covering a distance often of 20 ft. to the right and left, it is necessary to place and tier other boxes. It may be seen, however, that in order to lower a second, third, fourth or fifth box by the side of the first, it is necessary to move the boxes by hand while they are being lowered or move them after they have been lowered. In some cases a rope or a hook is attached to the case or box as it is being lowered and it is pulled to the right or left of the space directly below the overhead line. This scheme is, however, clumsy, slow, congestion-producing, and is another form of rehandling.

Area Serving. Mr. Fowler in Par. 36, calls attention to the important subject of area covering or space serving. Closely allied with the subject of tiering is this provision for covering any and every square foot of floor area of the station or pier with miscellaneous freight without the expense of moving it after it has been lowered.

In this connection, the kind of receptacle for holding the freight when it is being transported is important. Flatboards, nets, barrel hooks and slings are some of the means employed today. At one Southern terminal the slings are left about the packages until they are again to be moved by machinery, thereby saving 75 per cent of the labor for this second movement.

Continuous Rapidity. The third important principle, continuous rapidity of the transferring movements, means that one train of four or five trailers, each with its own electric hoist, as explained by Mr. Fowler in Par. 60, should follow one another so closely as to be almost continuous, but at the same time should consist of individual train units, so that from the loading or unloading point or tracks they may pass along the main track without hindrance and to the loading and unloading tracks without stopping. According to the well-known practice of railway engineers, the main track must not be frequently broken where continuous operation is desired, otherwise the continuous rapidity so essential to successful freight handling will be impossible.

To show the necessity for continuous rapidity the following data from one station are of interest. The number of dray loads received at this station, only 216 ft. long, from 7 a.m. to 4.30 p.m., was 748.

Average lb. per dray	1732
Average number of packages per dray	18
Number of packages received	14192
Number of hand-truck loads	5702
Average number of packages per hand-truck load	$2\frac{1}{2}$
Average weight per package, lb.	91
Average weight per truck load, lb.	228
Number of lb-ft.	417,539,430
Number of ton-feet	208,769

More than half of this was received in about 3 hours. To handle such a number of packages within the time specified shows that there is no time for delays, and one load must follow another directly. This is not an exaggerated condition but, if anything, may be said to be below the average.

FIG. 6 DIAGRAM SHOWING PLAN OF CRANE-SUPPORTED TRACK

Overhead Cranes. Numerous devices are used to obviate rehandling and to serve areas continuously, the best of which are slow indeed in comparison with the quick and numerous unit movements for freight handling. The traveling crane is one class of electric transfers excellently suited to shop work; but it is too slow and lacks the all-important factor, continuity, for freight service. If any machinery could be so adjusted as to retain all the well-known advantages of the crane, and in addition continuous rapidity, it would be the ideal system.

Acting upon this idea, noted by Mr. Fowler in Par. 52, crane makers, notably in Europe, have caused the traverser of the single-rail type of crane to pass from the tracks of the crane to and upon one side track, and by a loop to return to the crane from the other side. The great advantage of this scheme consists in the fact that there may be 20 traversers, each of which can move behind it a number of trailers with loads. The cross crane does not move with the load, it

is only to support a movable track. By making use, therefore, of the crane principle, allowing the traverser to pass upon the side track and having a number of traversers moving in circuits, always in the same direction, and running in trains with a number of hoists with tracks properly arranged, an ideal system with no rehandling, serving space and giving continuous rapidity is evolved. There may be several of these cranes, each carrying and supporting two or more cross tracks. This method is illustrated in Figs. 6, 7 and 8.

Referring to Fig. 7, *AB* and *XY* are the side tracks and *D* the movable cross or crane track, or as it may be called, a movable bridge track between the side or main tracks. *SS* are switches, whereby the carrier can pass from the fixed side to the movable cross track

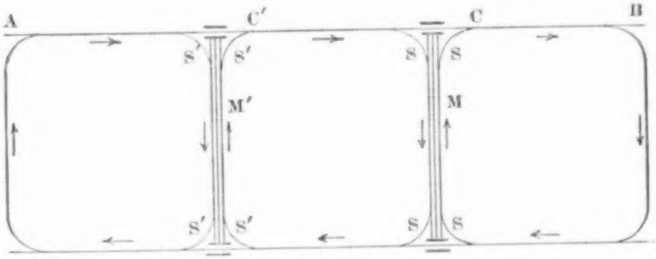


FIG. 7 DIAGRAM SHOWING ARRANGEMENTS OF MOVABLE CRANES, MOVABLE CROSS TRACKS, SWITCHES AND CONNECTING TRACKS

and also along the main side track by and beyond the cranes. *D′* is the position of *D* after having been moved.

Fig. 8 depicts two movable cranes, four movable cross tracks, switches and connecting tracks at the end. The direction of movement is indicated by the arrows. Loads, one after another, can be transferred with continuous rapidity by many transfer-hoists from any point within the side lines to any other point without rehandling. If the freight, after being deposited, is later to be moved, it is left upon the flatboards or in the slings, when it can be lifted by the overhead transfer hoist without any manual labor.

Fig. 9 shows another combination with diverse paths. The outer line of the two side loops may be outside a building, the walls of the building being within the closed loops, the curved ends of the loops

corresponding to the door openings or entrances. An example of this system may be found at the gas works in Brussels, where it is used to lift material from the purifying room below and spread it on any part of the regenerative floor, two traveling cranes carrying movable tracks being used.

At Bromberg, Germany, a traveling pedestal bridge is employed to support the movable loop track. By this means buckets of coal are shunted from the track running parallel to the building and dumped at any point in the storage yard, returning to the main track by the other side of the loop track.

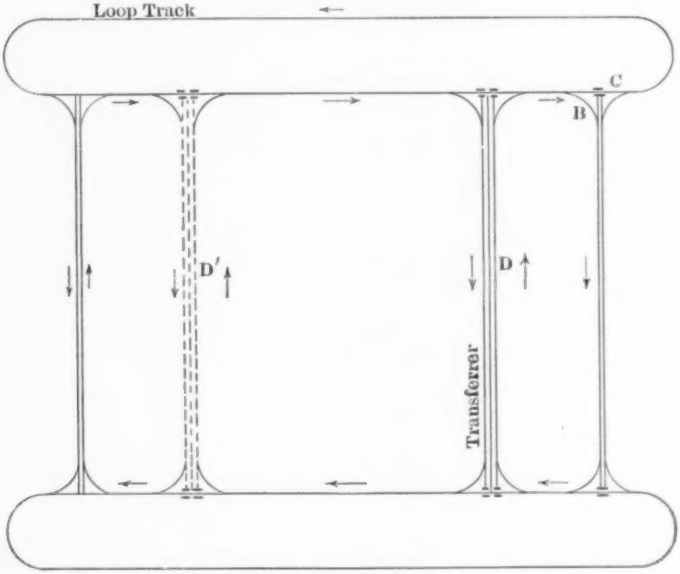


Fig. 8 Diagram showing Combination of Crane-Supported Tracks

It will be seen that terminal freight handling is a crane proposition, rather than one of conveying only, or preferably a combination of the two. It is also evident that line conveying is greatly limited and does not possess the same flexibility for terminal work as the area-serving crane modified and adapted to terminal freight handling.

A number of mechanical freight-handling plants are now being installed and projected by railways, chiefly in the West, as the Missouri, Kansas and Texas, in its new combined outbound, inbound and transfer freight station, in St. Louis, and soon it will be as difficult to find a hand truck as it is to find a horse car.

The essentials of successful terminal freight handling are, therefore, no rehandling, serving areas, and continuous rapidity in connection with the usual operating movements.

W. B. WATERMAN.[1] As Mr. Fowler has said, this problem of freight handling is one of terminals, and the solution is not to be found in the designing of new machinery, but rather in the *application* of well-known devices to the handling of freight, and the designing of an entirely new type of terminal suitable for use with machinery.

It is evident that if machinery is to take the place of hand labor, the unit load must be increased in order to increase the capacity of the station and warrant the investment. That is, instead of moving 250 lb. on a hand truck at a speed of 100 ft. per min., a load of 1000 lb., or more must be moved with machinery at a speed of 500 ft. per min. or faster.

It has been stated by railroad men and others that it is almost impossible, on account of the many classifications, to collect freight in order to obtain a larger unit load than is now obtained by a hand truck. This is especially true of outbound and transfer freight; the present practice being to take each piece or consignment separately, whether it is a small package or a piano, and truck it to the proper car. A truckman is not allowed to take packages for more than one car, as he cannot be relied on to put several packages in different cars.

It appears, however, that the solution of this lies in collecting the packages for any one car into one lot on the receiving platform, and transporting the collection by telpher to the proper car. This would give the desired increased unit movement. For example, assume the usual freight station accommodating 100 cars, as shown in Fig. 1. I would suggest a somewhat different arrangement of telpher runways, as shown in Fig. 9, the object being to provide a sufficient length of runways to accommodate enough telpher units for handling the tonnage of freight. The objection I find to layouts similar to Mr. Fowler's, and to a great many I have made and studied, is that the telphers are spaced so close together, they cannot move freely and accident or delay to one unit interrupts the entire system. In the arrangement shown in Fig. 9, each telpher runway over a platform forms a closed loop having a return path through the freight shed. There are, therefore, six independent telpher systems, each one tributary to the entire length of the shed, and each loop having two or three telpher

[1] J. M. Dodge Co., New York.

units as might be required to handle the freight. The total length of runways is 7300 ft. The telphers on any one loop can serve 20 cars, and 1000 tons per day can easily be handled by this system. There is not a switch involved in the operation to cause delay or interference. Nearly every square foot of floor space in the freight shed is covered, which, in the case of inbound freight would allow the contents of cars to be discharged and tiered over the entire area.

In the case of outbound freight, the idea is to have a space reserved in the outbound house of sufficient size to accommodate about 100 trucks or flatboards to be picked up by the telphers. Each one of

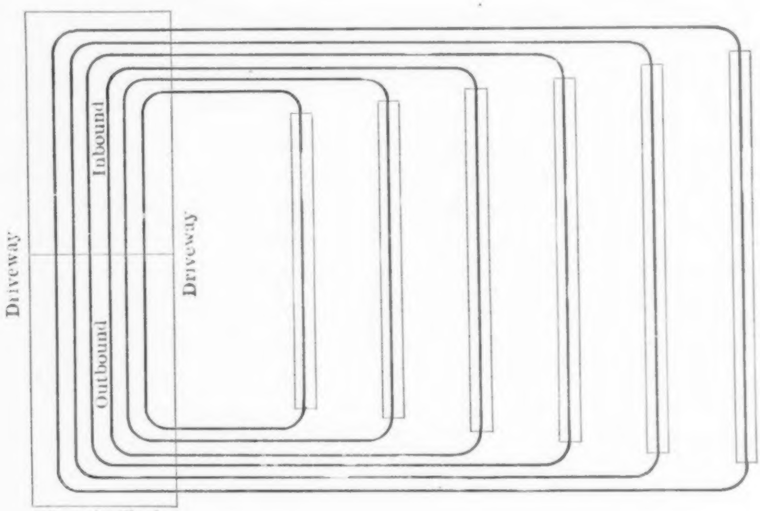


FIG. 9 DIAGRAM SHOWING ARRANGEMENT OF TELPHER RUNWAYS

these trucks would represent one of the railroad cars. As packages are received by dray, they would be weighed and checked and classified as usual and placed on the truck representing the car to which the freight was consigned. As soon as one truck was loaded with a sufficient number of packages, all for one car, it would be picked up by a telpher and set down near the proper car door. The next returning telpher would leave an empty truck in the space occupied by the one removed. All of the trucks would have designated locations under the proper telpher runways tributary to the cars they represent. The only hand trucking necessary would be in moving freight between drays and flat-boards, and this would be only across the shed.

The space occupied by these 100 trucks, assuming each 8 ft. long and 4 ft. wide, would be 3200 sq. ft., or a space 200 ft. long by 16 ft. wide. The floor space of an ordinary outbound house is about 20,000 sq. ft. It does not seem unreasonable to believe, therefore, that a proper terminal can be designed to take care of the proper number of trucks. In this way the freight can be allowed to accumulate on each truck until a sufficiently heavy load was obtained to warrant moving it by machinery, thus obtaining an increased unit movement.

While it would be desirable to eliminate all hand trucking and all rehandling, and to have the system cover every square foot of floor space and be absolutely flexible, it is not considered practicable at the present time to fulfil all of these conditions to the letter. That would mean the almost instantaneous evolution of a perfect system, such as there is no precedent for anywhere in the world. It is considered, possible, however, to approach these conditions so that perhaps 75 per cent of hand trucking can be eliminated, nearly all the floor space can be covered, and a sufficiently flexible system can be evolved (with some aid from the hand truck, which is a most efficient machine for short distances), which will greatly increase the capacity and decrease the cost per ton of handling, and which will warrant the investment.

W. J. Barney,[1] representing Commissioner Tomkins, of the Department of Docks and Ferries, New York City, spoke of the efforts being made to obtain better shipping facilities for New York City by assigning to railways the docks north of 23d Street on the Hudson River, thus providing much needed space for ocean steamships below that point.

This plan included the distribution of freight by an elevated railroad along the docks to the lower point of Manhattan Island. There are many mechanical difficulties to be met in connection with this plan, and Mr. Barney appealed to the members of the Society to come forward in a public spirited way as a number of engineers have already done, with suggestions for the solution of these difficulties.

Spencer Miller emphasized the importance of freight cars with movable roofs, so that the contents might be hoisted out by mechanical means. The Tehuantepec National Railway employs such cars, and hoists material directly from the cars into the hold of a ship by a complete system of cranes.

[1] Dept. Docks and Ferries, New York.

Mr. Miller also referred to the English system of freight shipment in which the railroad takes freight directly from the premises of the shipper by truck, and delivers it directly to the consignee in the same manner as is done by the express companies in this country. He believed that this method would prove economical to both shipper and railroad, because with carefully planned routes for the drays, it would be possible to have a full load almost continuously, instead of hauling a single package to the freight terminal, as is often the case at present. In addition, less storage space would be required with the entire control of the shipping process by the railroad company.

G. H. Condict[1] held that economical handling of freight is governed by three principles: continuous rapidity of movement, serving every foot of space, and no rehandling, and believed that by adopting a combination of methods now used in many manufacturing establishments, all of these features could be secured.

DISCUSSION AT BOSTON

E. W. Day[2] wrote that it was interesting to note the similarity of the system described in Mr. Fowler's paper to the following method to be employed by a large manufacturing concern for the handling of raw material. The apparatus was now in the process of construction and as yet untried. The problem was to handle inward-bound freight in the form of cases, casks, kegs, etc., and to store it in a warehouse of reinforced concrete 300 ft. in length and 80 ft. in width, served by a bridge crane of 75 ft. span throughout its length. The distance from the underside of the crane to the floor line was to be approximately 25 ft. The crane was to have a speed of 300 ft. per min., a trolley speed of 150 ft. per min., hoist speed 50 ft. per min., and a lifting capacity of 5 tons.

A sidetrack was to be located at one side of the warehouse for its entire length, openings being spaced 40 ft. on the centers to correspond to the length of a car, so that one spotting would place the car doors approximately opposite the doors of the building. A 10-ft. unloading platform, which was to be of the same grade as the floor and a part of the building itself was to intervene between the siding and building wall.

[1] Cons. Mech. and Elec. Engr., 20 Broad St., New York.

[2] Mech. Engr., Hood Rubber Co., Watertown, Mass.

A portable gravity-roller carrier was to be used from the inside of a car to the inside of the building. In order that cases might be placed on the automatic carrier with a minimum amount of hand labor 90-deg. reversible curves would be used inside the car. These cases would be delivered by gravity to the main floor of the warehouse, where they were to be weighed separately and, in many instances, unpacked to determine the net weights. They would then be repacked, placed on a platform having a rigid bridle, so that the crane operator could pick them up without help, and transported to any part of the warehouse. A number of these platforms would do away with any waiting either by the operator or laborers. The crane would also serve to bring the raw material to the point where it was to be started in process of manufacture.

In this scheme the four-wheel hand trucks were not to be dispensed with, since an overhead track system of the monorail type could not be found that would cover the ground as satisfactorily. Consequently a combination of the two methods would be used. The trucks were to be constructed in a manner such that they could be picked up by a crane or monorail-car operator and transported through various distances, in some cases 1000 ft. These trucks were also to be used instead of shelves, leaving the material stored to avoid rehandling, until it was ready for use.

With reference to the gravity carriers, Mr. Day believed they were destined to play a most important part in the handling of material and packages of all kinds. The ease and facility with which the portable types could be set up and operated even for a small number of parcels was worthy of note. The applications of these carriers in shoe-jobbing houses, wholesale houses, packing houses, brick houses, smelters and box factories had recently been investigated and in every case they were doing the work in an efficient manner at a saving of from 40 to 50 per cent over previous methods.

It had been suggested that the present way of teaming freight might be improved, and in this connection a removable automobile body or cage that could be placed by a crane on a four-wheel truck and delivered at the car door might be employed. By having several of these bodies an automobile could deliver one load at the freight house, load the empty body or cage and return for another. This would relieve the present congestion at the platform. It would also keep the truck, which represented a large investment, in operation a much greater portion of the time than is possible under the present methods.

This system, or something similar, is being used by the department stores of John Wanamaker and R. H. Macy in New York City.

D. B. Rushmore stated that electrical manufacturers in search of new applications for electrical machinery were giving considerable attention to the problems of freight handling. In the effort to reduce the cost of living there are few places in which so large a saving may be made as in this field. The problem must be studied from the standpoint of improving conditions in the many terminals which now exist, as well as the design of new ones.

The system described by the author has been in use for years in various modified forms but it has not found extensive use. A certain field of application may be found for it, but many of our great terminals would find it difficult to make use of the overhead telpher system because of lack of space.

In our large cities it is necessary to consider also the hauling of freight to and from the station. Signs seem to indicate that this will be done in New York and Chicago by underground subways. Electric vehicles are replacing the horse as a means of transporting freight in city streets and are of great help in facilitating the transmission of freight because they carry heavier loads and move faster. Another notable development is the recent adoption of baggage trucks operated by electricity at a number of important terminals.

The proposal to construct cars so that freight may be lowered in from the top is not a new departure in the handling of commodities, but simply an extension of the methods used in the department store and the factory for handling packages, and in the handling of ore, coal and grain.

R. H. Rogers[1] held that it was important not to underestimate the efficiency of the hand truck for handling freight. The truck is a lever of the first class, practically loads itself, may be transported up and down fairly steep inclines and when it reaches its destination a very simple movement unloads it and deposits the cargo practically in the space assigned to it. The stevedore and the truck form a complete unit with just enough brains to conduct the freight to the proper place.

With the telpher or similar systems it would seem that the extra time necessary to load the carriers over that for a truck, added to

[1] General Electric Company, Schenectady, N. Y.

the extra time needed to unload over that required for a truck, plus the additional distance it is necessary to go with a conveyor of this type as compared with the direct-trucking system, will constitute a handicap in time and labor that will be difficult to overcome with speed and large loads.

Mr. Rogers further expressed his belief that the average freight terminal with strings of cars side by side and connected by short gangways, is a very compact arrangement, permitting a trucker to go almost directly to the car for which his freight is intended. To make use of the transporter system, it is necessary to extend the yard and introduce a platform between each two strings of cars, with additional space if the first track is moved away from the station. Hence, there is not only a greater distance to travel because of the layout of the tracks, but also a greater area to cover.

Instances were cited by Mr. Rogers in which the cost of handling freight of various kinds ranges from $0.07 to $12 per ton and he also called attention to the fact that a great percentage of consignments are small, while many of the large ones must be broken up for shipment in different cars. Under these conditions it is difficult to make up the large units required for conveyance at low cost.

If all these conditions are considered, the present methods are more efficient than they seem to be. However, the difficulties are becoming greater and the time is approaching when nearly all of this work will be done by electrical or mechanical means.

F. W. Hodgdon[1] described the method used for handling raw sugar by the Spreckles sugar refinery of Philadelphia. The bags are discharged from the steamer down a gang-plank, and, after being inspected and weighed by the government, are carried over the wharf to the warehouse and piled up. The overhead telpher system in use 12 years ago is similar to that advocated by the author and seems to be the best for this class of freight, although it is suitable for any kind of package freight. Another advantage of the telpher system is that it provides more storage room for delayed goods.

Mr. Hodgdon also mentioned the difficulties of preparing and handling loads for the carriers and emphasized the necessity of loading cars by overhead methods.

R. E. Curtis thought that the journey of the package should not stop on the platform, but that mechanical means should be provided

[1] Engineer, Harbor and Land Commission, Boston, Mass.

for taking it from the car or placing it in the car without a stop. The business of a railroad is the selling of transportation, which should be done as promptly, directly and automatically as possible, and any break in the journey means loss in efficiency. Perhaps 20 per cent of the motive power used on railroads is engaged in switch service, and the casualties to men and property in railroad yards equal, if they do not exceed, those which occur on the road. Any saving that can be made in switching is, therefore, of great importance.

Three things must be done before it will be possible to attain the greatest efficiency: (*a*) the consolidation of transportation companies must be brought to the including of express drayage and other auxiliary transportation agencies, thereby eliminating much of the delay at various points; (*b*) a better method of grouping the smaller shipments must be adopted, either by improving the packages in which they are contained, or by some method of handling them to and from the cars in large quantities; (*c*) a free interchange of cars must be arranged so that the diversion and misrouting of cars may be eliminated. Although these improvements cannot be made immediately, progress toward the best efficiency must be in these directions.

J. P. Snow sympathized with Mr. Rogers and commended his ideas to anyone who was enthusiastic over the mechanical handling of freight, so far as railroad business was concerned. In reference to the alleged difficulty of spotting cars, he thought the tendency was now to build cars of uniform length, and when that desired end was reached, the spotting of cars would no longer be necessary.

Freight for a certain locality must be delivered by teams at a certain door. This brought the freight to the car in which it was to be shipped and the trucking distance was very short, especially if there were several lines of cars to load into—three, four or five, as mentioned in the paper—and the freight was transferred from the house into the cars very quickly.

In his opinion it was not advisable to store outbound freight. Shippers took no pains to ship their material in carload lots and fractional loads were bound to occur unless unreasonable delay was involved. He thought the idea suggested by Mr. Fowler that the railroad should operate vans to deliver freight to owners a good one and hoped it would be brought about sometime.

As to the mechanical handling of freight, it seemed best when adapted to water terminals where vessels lie at right angles to the track. At such terminals the tracks are necessarily dead-end. If

the vessel lies along the end of the wharf the freight must be tracked a long distance in order to get it into a sufficient number of cars, and it was difficult to make shifts and get the loaded cars out and the empty ones in if it had to be done while the vessel was being discharged. Some system like the telpher is splendidly adapted to these conditions and he thought that was the place for the railroads to try it.

For a layout of tracks and piers as shown by the author, he believed the storage battery trucks as used for baggage at many terminals were far preferable to an overhead-carrier system.

F. B. Freeman[1] called attention to the fact that the mechanical handling of freight at the railroad terminal is quite a different problem from that presented by a manufacturing establishment. In industrial plants, the packages are largely of the same kind, and can therefore be handled in groups and large lots. Such conditions are very favorable to handling by mechanical means. At the railroad freight house, however, practically every package, whether large or small, must be weighed separately, and immediately delivered to the proper destination car.

Under these conditions, it does not seem possible to handle large lots to advantage, nor can freight be tiered to any great extent, because it must all be accessible for prompt delivery to the consignee when called for.

G. H. Eaton[2] stated that as a traffic man he dealt directly with the public, and consequently received all the complaints. His experience in dealing with questions of delay had shown that the trouble is generally with the handling facilities of the terminals at intermediate points of transfer, rather than at the originating point. He also believed that the railroad should discourage the holding of goods in storage, rather than increase their facilities for doing so.

Most of the trucking at freight terminals does not exceed 25 to 50 ft., whereas, at water terminals, the distance is considerably greater and mechanical handling should therefore be first tried under these conditions.

G. T. Sampson[3] called attention to the fact that one of the first rules of railroading is: In case of doubt take the side of safety. This

[1] Ch. Engr., Boston & Albany R. R. Co., Boston, Mass.

[2] Genl. Freight Agt., Boston & Maine R. R. Co., Boston, Mass.

[3] Div. Engr., N. Y., N. H. & H. R. R. Co., Boston, Mass.

rule holds throughout the entire organization, and prevents or at least curtails the first adoption of new and untried methods. Where trains must be operated with unfailing regularity, the system for handling freight must be flexible. This is one of the strong points of the hand-trucking system, since it permits the shifting of men and trucks to suit the condition of the work. This system cannot be displaced until another method is found just as prompt and regular. Mechanical handling can only be fairly tried and tested in an extension to an existing large city terminal, where the kind and volume of traffic is regular and continuous, and by a corporation financially able to make the trial, even if it should prove unsuccessful.

Mr. Sampson believed that any successful system for the mechanical handling of freight must be as efficient as the cash-carrier system in a department store, and it must operate from the team to the car as surely as the small package containing the sales slip goes between the cashier's desk and the salesman at the counter. The real problem seems to be the design of a mechanical device, which will operate with the same certainty, whether loaded with a bulky single article weighing in hundred weights or with an accumulation of small packages.

Congestion of the incoming freight is due to the failure of the consignee to remove his goods promptly, and this forms one of the strongest arguments for the delivery of goods by the railroad with their own drays direct to the consignee.

G. E. Emmons.[1] said that during the past two years they have erected two large buildings which are to be used exclusively for storing material; one for finished apparatus, the other for raw materials. In both cases the buildings are equipped with tracks, overhead trolleys, single Coburn tracks, elevators, and in the case of the storehouse for finished apparatus, with an outside gantry crane which spans the space covered by two loading platforms. In common with others, they realized that there is a large expense involved in the handling of freight, and are doing all they can to minimize it.

[1] Mgr., General Electric Co., Schenectady, N. Y.

A COMPARISON OF AIR-BRAKING SYSTEMS FOR URBAN ELECTRIC RAILWAY CARS

A meeting of the Society was held in St. Louis on February 7, 1912, in which other engineering societies having representatives in that city were invited to coöperate. A paper on A Comparison of Air-Braking Systems for Urban Electric Railway Cars, by Charles W. Young and Charles A. Hobein, both of the United Railways Company of St. Louis, was read by the latter, describing the two systems, individual compressor and storage, commonly used for single cars in modern city service, with data on investment, operation, maintenance and depreciation costs.

The paper is confined to the discussion of the straight air system, as the only system used for single cars. This system allows the operator to admit air directly to the brake cylinder through the medium of an operating valve located in the motorman's cab. The release is likewise governed by the same valve. Two systems of straight air equipment are in use. In the individual compressor system the compressor is carried directly on the car and automatically maintains a constant pressure in the service reservoir, while in storage air systems the air is compressed to a high pressure in stations located in various buildings along the different car lines, and large storage tanks carried on the cars are charged by the use of street valves.

All equipment beginning with the service reservoir is practically the same with both systems. The service reservoir is a tank about 14 by 33 in. carried suspended underneath the car, and holding air for use directly in the brake cylinders at a pressure usually about 55 lb. The service reservoir is connected directly with the operating valve through suitable piping. Two types of operating valves are used: the Westinghouse valve, consisting of a simple slide valve operated by means of a rack and pinion, and the National Brake and Electric Company valve, consisting of two poppet valves, one for

Published in abstract only. The complete report may be consulted in the rooms of the Society.

admission and one for exhaust, and a slide valve to govern the rate of admission of air and the rate of release from the brake cylinder.

It is common practice to make the shoe pressure equal to the weight upon the wheel. Theoretically it might be made about three times the weight upon the wheel, but it is impossible to train the motormen to make such practice safe from the operating standpoint. The standard brake shoes of the United Railways Company of St. Louis are made of cast iron with chilled inserts, run about 4000 or 5000 miles, weighing when new about 25 lb., and when scrapped about 13 lb.

The car compressor in the individual compressor system is of the single-acting duplex type, with the motor bolted directly to the compressor case, and is designed to have the full voltage applied when at a standstill.

TABLE 1 RELATIVE ADVANTAGES OF INDIVIDUAL COMPRESSOR AND STORAGE SYSTEMS

	Storage System	Individual Compressor System
Interest at 6 per cent	$18,803.90	$26,628.05
Taxes	3,463.20	4,906.00
Depreciation	17,835.97	34,172.66
Operation	105,276.60	70,820.11
Maintenance	32,884.92	36,750.52
	$178,264.59	$173,277.34
Investments	313,398.44	443,800.84

In adopting a system of air brakes there are several factors to be taken into account, such as first cost, which is often the determining factor, total annual cost, and reliability.

Table 1 gives a summary of several tables presented by the authors to show the relative advantages of both systems from the standpoint of the original investor and operator. It is based on an air equipment for a total of 1372 cars.

From the report of the Electric Railway Test Commission it appears that the electric energy required to compress a cubic foot of air is 5.49 watt-hours in the storage system, and 3.99 watt-hours in the motor-compressing system. This results from the greater efficiency of the process of compressing the air directly to the pressure at which it is to be used. The difference between the electric energy used for braking in the two cases shows practically the same advantage

in favor of the motor compressor system, due to the fact that the air is more economically compressed, and delivered more economically to the brake cylinders. In the storage system more air is required from the fact that it is carried on the cars at a high pressure and leakage is difficult to avoid. In deciding upon the system to be used in any case, therefore, the question at issue is whether or not there is a saving in interest and maintenance in the use of the storage system which will offset the greater efficiency following from the use of the other equipment. The tests of the commission on the storage system in St. Louis brought out the fact that 95 per cent of the air compressed reached the cars.

In the discussion which followed the reading of the paper, RICHARD McCULLOCH[1] pointed out that the storage system can not be run economically on long interurban lines, but might be used to advantage in a smaller city of perhaps 50,000 to 100,000 inhabitants, where all the lines pass one point, especially if this point be in the neighborhood of a power station.

The following also participated in the general discussion: John Hunter, F. A. Berger, G. W. Lamke[2], A. S. Langsdorf[3], M. L. Holman, Jacob D. Von Maur[4], and L. C. F. Metzger[5]. The paper was illustrated by numerous lantern slides.

[1] Vice Pres. and Genl. Mgr., United Rwys. Co.
[2] Instructor Elec. Engrg., Washington Univ.
[3] Dean, School of Engrg., Prof. Elec. Engrg., Washington Univ.
[4] Supt. of Distribution, Laclede Gas Lt. Co., St. Louis, Mo.
[5] Asst. Engr., Terminal R. R. Assoc., St. Louis, Mo.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

FOREIGN REVIEW

The aim of the Foreign Review is to present, within the available space, the main data contained in the article indexed. Where possible, reference is made to English or American publications containing fuller information on the subject treated. Measures are given both in original units and their English equivalents. In many instances, engravings and tables are reproduced. Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

Air Machinery

Compressed Air Hammer with Double Piston (*Luftdruckhammer mit Doppelkolben*, Seb. Schuster. *Der praktische Maschinen-Konstruckteur*, May 9, 1912. 1 p., 3 figs. and 1 plate of drawings. *d*.) Description of what is said to be the largest *compressed air hammer* in existence, built by Richard Herz Co., Vienna, Austria.

Air Filters and Their Industrial Applications (*Les Filtres à air et leurs applications industrielles*, R. T. Serrure. *Fer et Acier*, April, 1912. 6 pp., 10 figs. *d*). Description of existing types of *air filters*, and brief discussion of their application in metallurgy, electric plants, and for hygienic purposes.

Cost Accounting

Expense Burden in Mechanical Construction (*Les Frais généraux dans la construction mécanique*, L. Dubus-Delos. *Technique moderne*, May 15, 1912. 3 pp. *p*). The author is opposed to distributing the *expense burden* per-man-per-hour-of-work, but thinks that it ought to be distributed per tool, in accordance with the work done by it, and the expense actually involved. A tool setter's hour of work does not require as much expense burden as an hour of work of a man at a large lathe, owing to the difference in power consumed, depreciation of the expensive tool, room occupied by the tool, etc. (This is practically the same system as that proposed by Sterling H. Bunnel, *The Journal*, December 1911, p. 1557.) The article gives, as an illustration, the application of this method to the cases of two shops: one of 35, and the other of 100 men.

Firing and Fuel

Utilization of Coal-Tar Oil for Heating and Power Production (*Teerölverwertung für Heiz- und Kraftzwecke*, R. Hausenfelder. *Stahl und Eisen*, May 9, 1912. 11 pp., 20 figs. *dp*). The article is devoted mainly to the description of *furnaces and furnace appliances for burning coal-tar oil, naphthalin*, etc. The production of coal-tar oil rose during the last five years in Germany from 150,000 tons to 400,000 tons, and new uses had to be found for it: hence the experiments (now successful) with its use as a fuel. Its application is especially wide in metallurgical plants for puddling furnaces, mixers, Siemens-Martin furnaces, and for enriching blast-furnace gases where they are used for power production. It is also used in the Diesel motor (Cp. *The Journal*, June 1912, p. 909). The author is, however, against the use of raw coal-tar as fuel, because it contains up to 10 per cent. water which has to be paid for, carried, and freighted as tar, and which is useless, or even harmful, in combustion. It is further only a raw material, and contains valuable elements which may be extracted as by-products, but which are lost when the tar is consumed as fuel. The coal-tar is not well adapted to be used as a fuel, at least in the present furnace, because it is viscous, and apt to clog the nozzles; also, notwithstanding many experiments in this direction, it cannot be used in a Diesel engine with any reliability of operation.

Coal-Tar Firing plant constructed by Müller and Korte (*Die Teerfeuerung von Müller & Korte. Zeits. für Dampfkessel und Maschinenbetrieb*, May 17, 1912. 1½ pp., 2 figs. *d*). Description of a water tube boiler adapted for coal-tar oil firing, and data of tests of same. The coal-tar firing is a very important problem for the German engineers, owing to the large amount of this material obtained as a by-product of the gas and coke industries, and absence of local petroleum oil industry. In the tests it was found that the coal tar, with a heating value of 8236 WE per kg. (14,800 b.t.u. per lb.), evaporated from 9.3 to 9.65 kg. of water per kg. of combustible, the boiler efficiency being from 71.6 to 75.2 per cent.

Utilization of Hot Exhaust Gases from Blast Furnaces for the Production of Steam (*Die Verwertung der heissen Abgase von Flammöfen zur Dampferzeugung*, F. Peter. *Stahl und Eisen*, May 16, 1912. 6 p. *g*). The author refers mainly to puddling and reheating furnaces. The metal in these furnaces is heated in most cases to 800 to 1200 deg. cent. (1472 to 2192 deg. fahr.); in order, however, that the metal may reach such a temperature the temperature of the hearth must be considerably higher, and so must be the temperature of the exhaust gases. The efficiency of such a furnace is therefore very low, and may be expressed by

$$\varphi = \frac{t_a - t_e}{t_a}$$

where φ is the efficiency of the furnace, t_a initial temperature, and t_e final temperature of the hearth. For $t_a = 1400$ deg. cent. (2552 deg. fahr.), and $t_e = 1000$ deg. cent. (1832 deg. fahr.), the efficiency is

$$\varphi = \frac{1400 - 1000}{1400} = 0.29$$

or about 30 per cent, and even that is not the real efficiency, since the above

calculation does not take into consideration radiation and conduction losses.

The author goes fully into the question whether or not an attempt to utilize the heat of exhaust gases would interfere with the proper *working of the smokestack*, and finds that the weight of gases carried off by the stack remains, within certain limits, practically constant, notwithstanding some variations in the temperature of the exhaust gases. The cooling of the gases by the utilization of their heat for the production of steam will therefore not interfere with the working of the stack, provided that the draft of the stack is still strong enough to overcome all the resistances and to give the gases a sufficient velocity. Since in the majority of cases the draft is anyhow throttled by a damper, the utilization of the heat can have no ill effect on the working of the furnace.

If the boiler plant utilizing the heat could be constructed right on the reheating furnace, the efficiency of utilization would be

$$\varphi' = \frac{t'_a - t'_e}{t'_a}$$

where t'_a is the initial, and t'_e the final temperature. Taking usual conditions, the efficiency would be

$$\frac{1000-300}{1000} = 0.70$$

Actually, however, the *boiler plant* will not be *placed* right on the reheating furnace, but some distance away, and the efficiency will therefore be lower, probably about 60 per cent. The change in the total efficiency of the plant is therefore raised from 30 per cent theoretical to 80 per cent theoretical, or from about 20 per cent actual to more more than 60 per cent.

The next thing to be considered is the fuel and its utilization. It is very important in a reheating furnace that the gases have a certain composition, so as not to injure the metal by excessive oxidation. This makes it preferable to admit to the furnace too little rather than too much air, loss of fuel due to incomplete combustion being preferable to possible loss of the metal due to excessive oxidation. The amount of this loss of fuel depends on the construction of the furnace and conditions of operation, but the author has found in one case not less than 6 per cent of carbon monoxide in the exhaust gases of a reheating furnace, while M. Phillips (*Stahl und Eisen*, January 4, 1912, p. 12) found as much as 9 per cent carbon monoxide in a semi-producer type furnace exhaust gases.

The use of exhaust gases for the production of steam is more economical than for preheating feedwater or superheating steam. In the first case the difference between the temperature of the gases and water is great, and either only part of the heat in the gases will be used, or a very large amount, more than is required in a steel plant, will have to be preheated. Superheating of steam by exhaust gases can be easily done, but its economy is impaired by the fact that the working of the furnace does not always happen at the rate that steam is wanted. With a slight demand for steam it may be superheated too much, while the opposite may happen when the demand for steam is too large. The article is to be continued.

Internal Combustion Engines

Report of an Investigation of a Peat-Gas Plant of the Görlitz Machine and Foundry Company (*Bericht über die Untersuchung einer*

Torfgasanlage der Görlitzer Maschinenbauanstalt und Eisengiesserei A.-G., H. Baer. *Zeits. des Vereines deutscher Ingenieure*, April 6, 1912. 4 pp., 12 figs. *dc*). Description and data of tests of a *Görlitz peat-gas producer and gas engine*, with drawings of the latter (for a full description see *Zeits. des Vereines deutscher Ingenieure*, 1911, p. 368 ff., Heinz Die Ausnutzung unserer Torfmoore). The most interesting part in the construction of the producer is the care taken to prevent the escape of heat, which is very important in this case owing to the considerable consumption of heat in the evaporation and decomposition of the water in the peat. Air is introduced into the producer in two streams, one through the producer jacket so as to take up the heat of radiation, and the other in such a way as to be strongly preheated by the gases produced. The arrangement is so efficient that during the tests at the East German Exhibition in 1911 in Posen the cylinder jacket and gas outlet pipe were found to be only hand-warm. The tar-containing parts of the fuel are consumed in the producer itself, while the gases of incomplete combustion and products of distillation are generally forced to pass through the zone of incandescence instead of being allowed to escape through the gas outlet pipe.

The analysis of the peat gas shows it to contain 23 to 25 per cent of moisture and about 4 per cent of ashes. The remarkably low percentage of moisture is said to be due to the hot and dry summer of 1911. The average heat value 3949 WE per kg., or 7128 b.t.u. per lb. Two tests of 8 hours 3 minutes and 8 hours 11 minutes were made, with the following results as to the consumption of peat, and cost of power:

TABLE 1 DATA OF TESTS OF A GÖRLITZ GAS PRODUCER PLANT

Number of Test	1	2
Consumption of peat per kw-hr. at the switchboard, kg	1.555	2.41
lb	3.41	5.3
Consumption of peat per effective h.p.-hr., kg	0.99	1.45
lb	2.19	3.19
Consumption of peat per i.h.p.-hr., kg	0.82	1.16
lb	1.80	2.55
Fuel cost per kw-hr., at the switchboard, pf	0.62	0.965
cents	0.15	0.26
Fuel cost per effective h.p-hr., pf	0.396	0.580
cents	0.9	0.14

While the first cost and attendance are said to be about the same as in the case of a steam plant, with at least equal reliability of operation.

Improvement of Internal Combustion Motors Through Preheating of Air (*Verbesserung von Verbrennungsmotoren durch Vorwärmung der angesaugten Luft*, A. Nougier. *Die Gasmotorentechnik*, May 1912. 2 pp., 1 fig. *dt*). Translation of the first part of the article in the *Génie Civil*, February 24, 1912, under the same title, fully reported in *The Journal* for April, p. 615. Attention of those who may use the original French or the above German translation is called to the error in the heading of the

third column of the figure, where the exponents of $\frac{p_1}{p_0}$ and $\frac{v_0}{v_1}$ are omitted. They are correctly inserted in the *Foreign Review.*

AUTOMATIC SPARK ADJUSTMENT (*Selbststätige Zündverstellung,* Löw. *Zeits. des Mitteleuropäischen Motorwagen-Vereins,* End April, 1912. 2 pp. *gh*). The first automobiles had no spark adjustment. Benz was the first to introduce it, but placed it so that the driver, to change the spark, had to open the back cover, after having previously stopped the motor. One of the reasons why the spark adjustment was not placed directly at the driver's seat was that the old motors had a great many more levers than the present ones, and the designer was naturally unwilling to make it look still more complicated. Fiat was the first to introduce a centrifugal spark adjuster, but took it off shortly after, so that the regular use of automatic spark adjustment dates really only from 1910, when its application was made commercially possible by the introduction of Eisemann's magneto.

What the centrifugal spark adjuster does is to advance the ignition at high speed, and retard it at low speed, so that the purpose of the adjusting device is to insure the *most advantageous time of ignition,* but the most advantageous time may mean either the time which insures the most economic working of the motor, with the least consumption of fuel, and minimum stress of its parts, or it may mean the condition under which the output of the motor is at its maximum. These two things are by no means identical, and while the driver may want, under certain conditions, to get out of the motor all it can give, he will regularly try to run it as economically as possible. But the automatic spark adjuster can regulate the adjustment only one way, and adjustment by hand is therefore more flexible.

A further disadvantage of automatic adjustment is its aptness to get out of order. The governor springs change in tension, the revolving parts get out of balance owing to the shocks and vibrations, and as a result the time of ignition is displaced, often very disadvantageously, the worst feature being that it is very difficult to discover whether the ignition is really set as advantageously as believed. Even when the ignition was set at the factory and carefully tried, there is good reason to believe that it would have to be changed after a few weeks of actual work on the road; but whether it is so, and just how much it has to be changed, can be found only by new careful tests, which the ordinary automobile owner is either quite unable to do, or in a great many cases will do incorrectly.

But even were it possible to make automatic spark adjustment perfectly reliable, it would still not answer its purpose of insuring the most advantageous time of ignition. The best *ignition time depends* not only on the speed of the motor, but also on the working pressure and temperature of the mixture. A strongly throttled mixture has to be ignited earlier than a highly compressed one, and a hot mixture later than a cold one. But the centrifugal regulator is not affected by this change in compression and temperature at all, and regulates therefore the time of ignition really in accordance with the alterations in one variable, while there are several others of at least equal importance.

Automatic spark adjustment may be, and is, used when desired without danger of the automobile refusing to work (which is proved by the fact of there being in operation many cars and trucks with no adjustment at all), but its use cannot be considered as an improvement on adjustment by hand.

International Exhibition of Internal Combustion Motors in St. Petersburg (*Die Internationale Ausstellung von Verbrennungsmotoren in St. Petersburg*, N. Bikoff and G. v. Doepp. *Die Gasmotorentechnik*, May 1912. 4 pp., 7 figs. *d*). Description with drawings of four-stroke cycle motors built by the Kolomna and Sormovo Works (Russia) and the Südwerft A.-G., Stockholm, Sweden. The first and last are marine motors, and both reversible. In the case of the Kolomna motors reversibility is secured in the following way: The motor is a four-cylinder, 300-h.p. engine, with a common camshaft to all the cylinders, driven from the main shaft by means of an auxiliary shaft placed in the middle of the motor between the second and third cylinder. Opposite to each cylinder there is placed on the camshaft a double series of cams, for going ahead and astern, controlling the admission and exhaust valves, the naphtha valve and the air valve for starting the motor. The levers of the transmission gear are on the shafts *B* (there are two of them: one for going ahead, and the other astern); on each shaft there is a hand lever *K* which can be placed in any of the positions corresponding to: (1) normal work of the motor; (2) all valves out of operation; (3) starting the motor.

The reversing mechanism works as follows: The position of the lever *K* in Fig. 1 corresponds to normal working of the motor, i. e., going ahead. Should the lever be turned through 45 deg., the naphtha admission valve will be closed by the respective cam; at the same time the naphtha pump will be put out of action, and compressed air admitted to the cylinders *H*. In these cylinders there are pistons which are kept in their upper position by a spring, while the respective piston rods take a position just above the valve spindles, but do not touch them as long as the valves remain closed. As soon, however, as the compressed air presses the pistons down, the valves, with their levers, begin to move sidewise, and the rollers of the levers are lifted up by the cams, thus permitting their displacement, with the help of the levers *G*, along special springs located in the body of the shaft. Then the lever *K* is placed in its third position, in which the lever of the exhaust valve is permitted to come in contact with its corresponding cam on the shaft, while the naphtha pump remains cut out. As a result the compressed air is allowed to flow out of the cylinders *H*, the air and exhaust valves rise, and the rollers of their levers come in contact with the respective cams. When the motor reaches its normal speed of rotation, the lever *K* is placed vertically.

These motors are used mainly for passenger ships on the Wolga, in Eastern Russia, and appear to work satisfactorily.

Cheap Motive Power from Gas Producers with Recuperation of Ammonia (*La force motrice à bas prix par les gazogènes à récupération d'ammoniaque*. F. Charles. *La Houille Blanche*, March 1912. 8 pp., 9 figs. *d*). General, rather popular discussion of the production of power

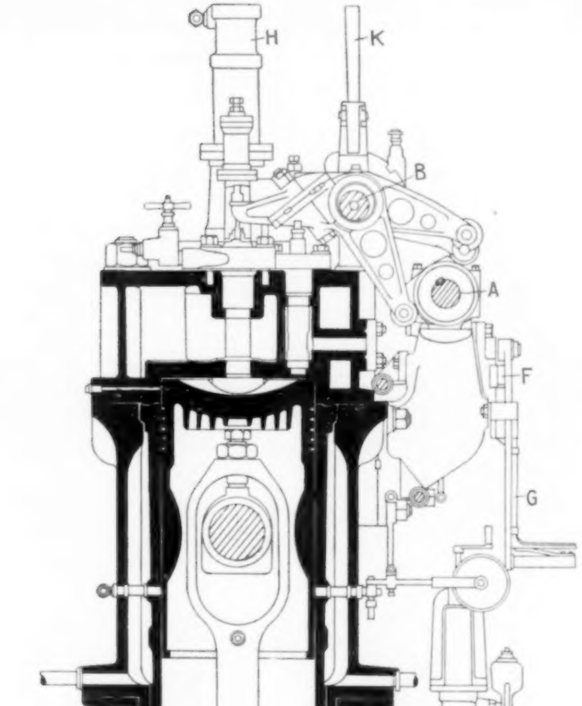


Fig. 1 Four-Cycle Reversible Marine Motor of the Kolomna Works

from blast furnace gases, gas producers, and gases from by-product coke ovens, with several illustrations showing the heat balances of the steam and gas engines and blast furnace. The article may be used for popular lectures and talks to employees.

Machine Shop

The Cementation of Iron by Solid Carbon (*Sur la cémentation de fer par le charbon solide*, G. Charpy et S. Bonnerot. *Revue de métallurgie*, May 1912. 15 pp., 9 figs. *e.*) Detailed account of the experiments briefly announced before (Cp. *The Journal*, January 1912, p. 120.) The authors have found that at a temperature of 950 deg. cent. (1742 deg. fahr.) no cementation is produced when no gases are present, but there is reason to believe that carbon does diffuse through the iron, as appears to be indicated by structural changes in cast iron and steel heated above the critical points. It is difficult to state, however, what may have been the influence of the occult gases in the metal in such a diffusion. As regards adherence between carbon and iron, the experiments have not been conclusive. It has in no case, however, been anything like the adherence which exists between the graphite and the ferrite in cast iron.

Galvanization of Iron and Steel. Part IV: Sherardization (*Le Zingage du fer et de l'acier. La Shérardisation*, A. Sang. *Revue de métallurgie*, May 1912. 18 pp., 11 figs. *dt*). Continuation of a series of

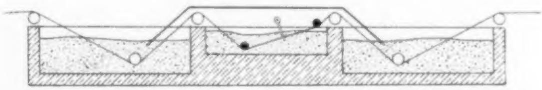


Fig. 2 Sang Continuous Process of Electrically Galvanizing Steel Wire

articles on various methods of galvanizing iron and steel (beginning in January 1912. Cp. *The Journal*, March 1912, p. 419). The author discusses sherardization mainly on the basis of the work of Dr. C. F. Burgess, of the University of Wisconsin, and Dr. A. S. Cushman, and describes several types of furnaces for this process. He describes also his own continuous process of *sherardizing wires* by heating them *electrically* while they are being drawn through a bath of zinc gray. As shown in Fig. 2, the wire, which does not have to be particularly clean, passes first through a layer of sand, and then below a cover into the zinc gray bath; the part of the wire between the contact points is maintained at a red heat. The wire comes out from the bath in the same manner as it went in, and may be cooled in the air. There are, however, certain essential rules that must be observed in order that the process be successful. There must be some arrangement for making the wire move sidewise, so as always to bring it in contact with fresh particles of zinc gray, and to prevent the latter from forming cavities where the wire would slip without meeting any galvanizing metal. The zinc gray must have attained a certain temperature, but since it is in a receptacle made of refractory material, it is enough to leave the wire stationary in the bath until it reaches the desired temperature, and only then set it in motion. The most difficult part of this installation,

however, is the arrangement of the contacts, because if this is unsatisfactory, only a single point on the wire will be heated, and the wire will come out of the bath red hot, but not sherardized. Besides being galvanized, the wire is also annealed.

New Industrial Burners (*Neure gewerbliche Heizbrenner. Elektrotechnischer Anzeiger*, May 19 and 26, 1912. 3 pp., 18 figs. *d*). Review of German burners for welding and cutting metals. The Jurgens gas blower (Fig. 3, 1 and 2) is a combination of a Bunsen burner and a blowpipe. The blower rotates on the support *f*, and is provided with air and gas ducts *l* and *g*, the air duct *l* connecting with the gas duct when the cock *h* with its angle bore *w* is placed in a suitable position. The gas duct *g* is further divided into two separate ducts k^1 and k^2 leading to the respective plugs of the cock *h*. The gas flows through these ducts into the burner pipe *b* from which either a Bunsen flame or a blowpipe flame may be produced. In the first case the air admission sleeve is placed so that its holes are just over the holes in the burner pipe, giving free admission to the air. The rotation of the sleeve is accompanied, by means of the pin *m*, by a displacement of the slide valve *sch* opening to the gas a passage into the burner pipe through the little holes p^1 and p^2. If the burner is used as a blowpipe, the sleeve *z* is brought to where it covers the holes in the burner pipes, whereby the slide valve *sch* is placed so that the large openings d^1 and d^2 are brought over the ducts k^1 and k^2, and compressed air let on.

Fig. 3, 3, shows the soldering acetylene heated iron of Tr. Baumann in Winterlingen, Germany. The gas pipe *a* is provided with a cock *c* and ends in a nozzle *d* enclosed in the shaft of a spherical burner *e*, this shaft being provided with air admission openings *f*. The nozzle *d* ends in a conical extension *g*, the purpose of which is to produce a narrow flame directed on the iron *i* surrounded by the jacket *h* with its openings *q*. There is also a spring *n* which can be regulated by the screw *o* so that its tip *p* closes more or less the opening of the nozzle *d*, and thus makes the flame strong or weak, as desired. A wire gauze screen is provided at *k*, to prevent backfiring.

In the production of burners using liquid fuel, more economical thermally and less dangerous than acetylene burners, two improvements are credited to Edward Grube in Alt-Rahlstedt, Germany. The liquid fuel must of course be evaporated before it can mix with the air. The first is shown in Fig. 3, 4. A burner with a single superheater coil *A* from which oil vapor is conducted to the distributing member *B*, and is supplied simultaneously to the injectors *E* and nozzle *L*. The oil vapor formed in the superheater coil *A* produces a narrow flame at the exit from the nozzle *L*, as in an ordinary blowpipe, but serves also to feed the welding burner *F*. For this purpose part of the oil vapor is led aside into the injector *E*, and mixes there with the oxygen. To start the burner, the superheater coil *A*, with all valves closed, has to be heated by some outside source of heat. To use the burner for welding purposes, the cock *H* has to be opened, and oxygen admitted ta the injector *E* through the pipe *D*.

In the second burner of the same concern (Fig. 3, 5), the oil which is led to the burner through the pipe *A* under pressure, enters into the car-

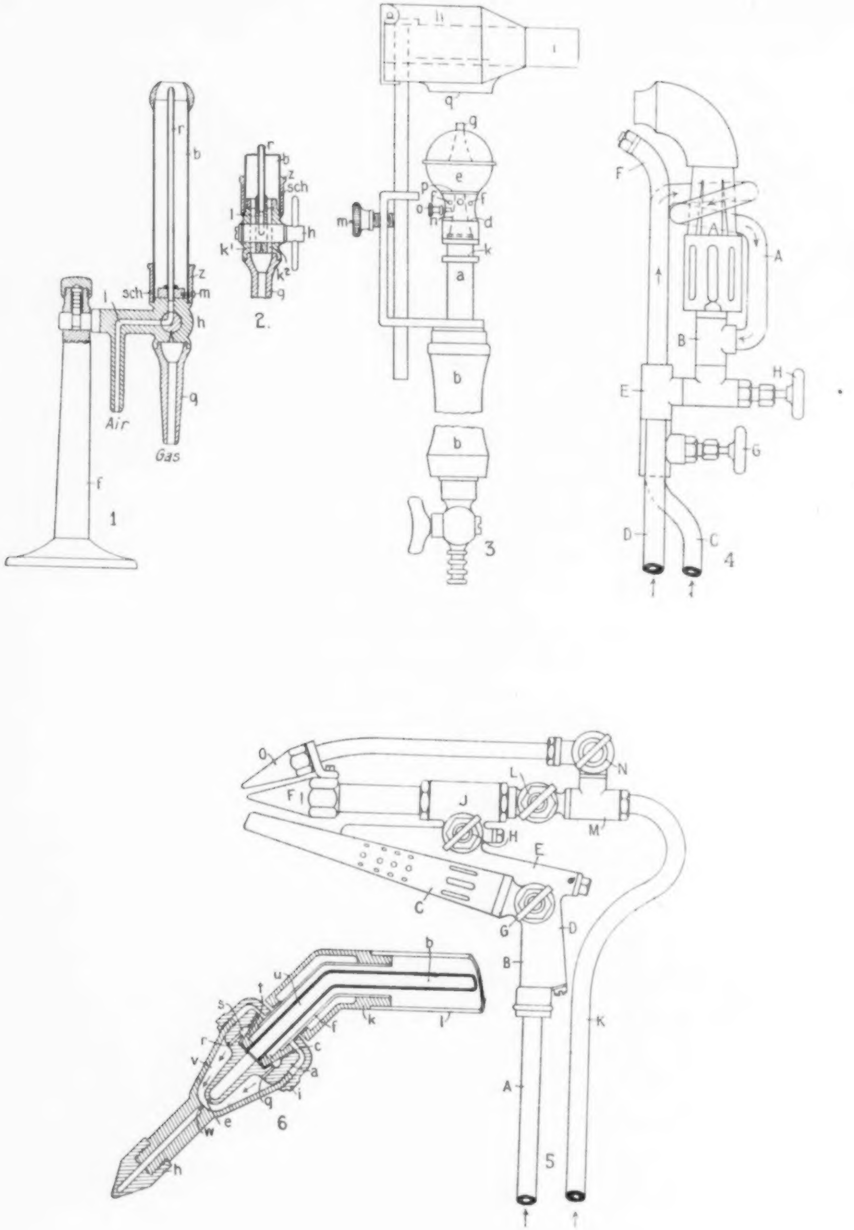
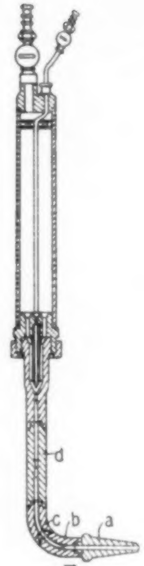


FIG. 3 BURNERS (BLOWPIPES AND TORCHES)



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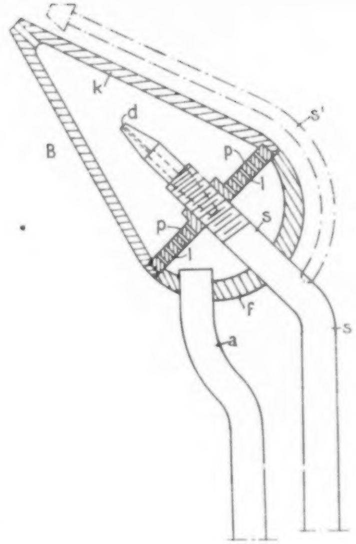

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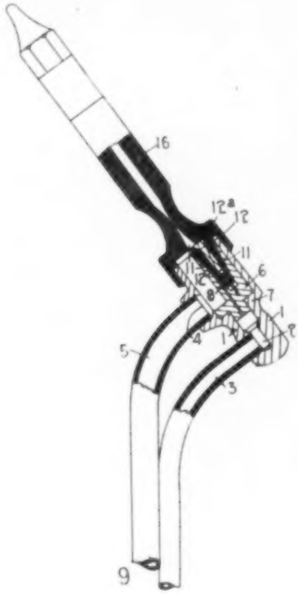

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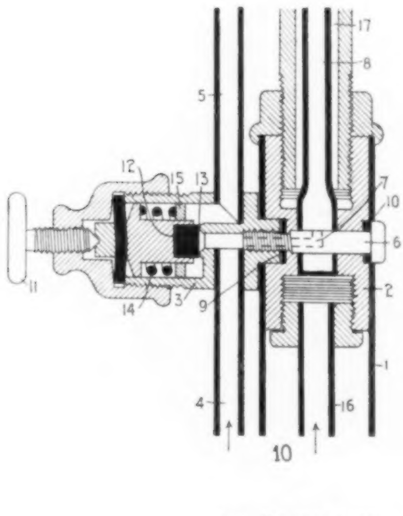

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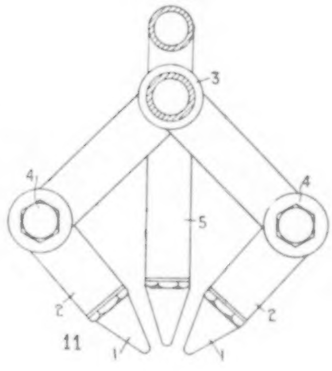

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FOR WELDING AND CUTTING METALS

buretor *B* of the blowpipe *E* as well as through a side duct *D*, into the carburetor *E* of the welding pipe *F*. The valves *G* and *H* regulate the supply of the oil vapor. The carburetor *B* is heated by the heat conducted through the metal from the pipe *C* of the blowpipe, while the carburetor *E* is directly surrounded by the flame of the blowpipe; from *E* the oil vapor passes into the injector *J*, and mixes there with the oxygen coming through the pipe *K*, the flow of the oxygen being regulated by the valve *L*. A branch pipe *M* with cock *N* permits also the regulation of the supply of oxygen flowing under high pressure to the torch for cutting metals *O*.

To obviate the necessity of having several burners of various sizes for different kinds of work, J. Ammon in Schöneberg (near Berlin, Germany) designed a burner (Fig. 3, 6) for welding which may be fitted with different nozzles for different kinds of work. The part *gh* is a nozzle body provided with properly dimensioned ducts for oxygen and fuel gas, with the nozzle and outer tube in permanent connection. The nozzle body *de* is slipped over the hollow conical nipple *c* connected with the oxygen pipe *b* and combustible gas chamber *l*, the two being connected when necessary by the cap screw *i*. The oxygen flows through the pipe *b* into the duct *w*, and out through the burner nozzle *h*. The fuel gas is drawn by the suction, produced by the flow of oxygen, through the duct *t* into the passage *s*, and thence through the duct *r* into the combustion chamber *v*. Another burner, on the same principle, but somewhat different in constructive details, has been designed by W. Widmann in Stuttgart, Germany.

The vapor nozzle of the welding burner of the Rheinische Gesellschaft fur autogene Metallbearbeitung m.b.H. in Cologne, Germany (Fig. 3, 7), consists of several exchangeable parts. The nozzle proper, consisting of three parts, *a*, *b* and *c*, is screwed to the mixing tube *d*, these three parts being provided with similar threads, so that they may be set at any desired angle to the axis of the mixing tube.

The burner of M. Imhoff, of Berlin, Germany (Fig. 3, 8), which may be used both for welding and cutting metals, is constructed so that the oxygen cannot get into the gas pipes. The pear-shaped burner *B* consists of a semi-spherical base *f* and conical vapor nozzle *k*, divided by the plate *p* having a large number of small holes *l* arranged in concentric circles. Acetylene is brought through *a*, oxygen through the pipe *s* passing through the base and plate *p*, and provided with the nozzle *d*. The mixture of oxygen and gas flows out through the nozzle *o*. When the burner is used for cutting metals, an additional stream of oxygen is supplied through the branch piping s^1. The peculiar shape of the burner permits of cutting a number of holes in the plate *p* such as to allow always a sufficient supply of gas to flow through, with no danger of backfiring. The conical extension *k* is said to favor the mixing of the two gases.

Instead of making provisions for exchanging nozzles, the admission of oxygen may be regulated, as is done in the burner of the Apparate-Bau-Anstalt Schmalkalden G.m.b.H., in Schmalkalden, Germany (Fig. 3, 9). The oxygen pipe 3 opens into the chamber 2, while the acetylene pipe 5 is led to the side opening 4. The headpiece 6 is screwed into the casing 1, and is provided with a central duct, with the front part of 6 eccentrically located, and fitted with cone 11 having in its turn longitudinal grooves 12

opening into ducts 12^a. These ducts are cut in special nozzle-shaped pins connected with cone 11, are of different diameters, and, like the grooves 12, are not limited as to number. Since the path of the oxygen lies through 12^a enclosed in the cone or pins connected with it, the regulation of the oxygen is not affected by regrinding.

What is claimed to be a new arrangement for distributing the oxygen in burners with a single oxygen piping is embodied in the burner shown in Fig. 3, 10, constructed by J. Knappich in Augsburg, Germany. The oxygen regulating valve 3, with its admission and discharge piping 4 and 5, is fastened by the screw 6 to the body 2 enclosed in a tube protector 1. The screw passes through the duct 8 for the admission of oxygen for the preheater flame, this duct being closed below the screw, and the screw being provided with a bore 7 connecting the oxygen supply pipes 4 and 8. The inside diameter of 8 is so large that there is always a sufficient area for the passage of the gas, independent of the position of the screw 6. The disks 9 and 10 act as packing. By means of the screw 11 the valve 3 can be closed or opened, according as the valve cone 12 is pressed against its seat 13, or lifted from it by the spring 14 having as purchase the disk 15. The fuel gas pipes 16 and 17 are tightly fastened to the body 2, the two

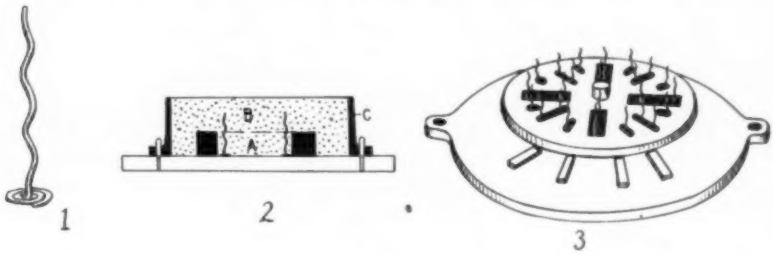

Fig. 4 H. C. Klotz Mold Spiral and Its Application

pipes being connected by the ducts 18. When valve 3 is open, the oxygen brought by pipe 4 flows into 8 as well as into 5. When the valve is closed, the admission of oxygen into the oxidation pipe 5 is stopped, but the gas continues to flow through 7 into the pipe 8.

In the torch for cutting metals of R. Moritz, of Wasquehal, France (Fig. 3, 11), the nozzles of the fuel gas supply pipes are on pin joints, thus permitting the regulation of the heated space opposite the oxidation nozzle. Oxygen is supplied by the pipe 5, and fuel gas by the nozzles 1.

A New Interesting Expedient in the Foundry (*Ein neues, interessantes Hilfsmittel in der Formerei. Giesserei-Zeitung*, May 15, 1912. 2 pp., 6 figs. *d*). The formation of a core in a pattern depends on many things, e.g., quality of the sand, execution and design of the pattern, molding machine used, etc., and does not always succeed, especially when the height of the core is considerably in excess of its diameter. This applies particularly to the case when lifting-type molding machines are used. With turnover-type molding machines the cores can be made easier, because with this type of machine the pattern is lifted out of the mold, and the

sand is not disturbed. But even there it happens often that the sand is pressed so hard into the core hole that when the pattern is lifted, it is torn off, and carried away with the pattern.

To prevent this the firm H. C. Klotz, in Hamburg, Germany, patented the *mold spiral* (*Formspirale*) shown in Fig. 4, 1, and made of hard wire, with the upper part in the form of a spiral, and the base wound like a snake. The coils of the spiral of the vertical part must not be too close to one another, to allow the sand space to get well in. Fig. 4, 2, shows how the spiral is applied in setting the mold. The spirals have to be set as close to the edges of the core as possible; if the core is of angular or otherwise irregular form, the spirals have to be set in the angles, or wherever there is danger of the piece breaking off. Fig. 4, 3, shows how by means of this spiral a face plate can be made without cores. The article states that in one particular foundry there was a saving of 160 cores per day in the manufacture of this one face plate due to the use of the mold spiral.

THERMIC AND MECHANICAL TREATMENT OF METALS IN THE SHOP: TEMPERING (*Traitements thermiques et mécaniques des métaux a l'atelier. Revenu*, F. Robin et P. Gartner. *Revue de mécanique*, April 30, 1912. 23 pp., 34 figs. *dt*). A short statement of the theory of tempering, and description of the various furnaces used for this purpose.

Measuring Apparatus

LIMITS OF USE OF HIGH TEMPERATURE THERMOMETERS (*Die Brauchbarkeitsgrenze der hochgradigen Thermometer*, H. F. Wiebe. *Deutsche Mechaniker-Zeitung*, February 1 and 15, 1912. 10 pp. *e*). Experiments made at the German Government Bureau for physical and technical investigations (Physikalisch-Technische Reichsanstalt) have shown that (*a*) Although the *thermometers* used for these tests, and made of *Jena borosilicate glass* 59^{III}, were submitted by the manufacturer to an aging process of three to four days' duration, these thermometers have nevertheless shown a raising of the ice point up to 7 deg. after a further aging process of about 160 hours at a temperature of 500 deg. cent. It may be accepted, therefore, that it requires an aging of at least ten days at 500 deg. cent. to obtain a constant position of the ice point, with variations not exceeding 0.5 deg. cent. There is, however, no need for a subsequent slow and long cooling, and after a sufficiently long heating at 500 deg. cent. the thermometer may be simply left in the bath to cool down of itself. The reason for the cooling having little effect on the position of the ice point is the slight thermal depression for this kind of glass. (*b*) The limit up to which a high temperature thermometer of Jena borosilicate glass 59^{III} may be used is 510 to 515 deg. cent. The German regulations prohibit the division of such thermometer scales above 510 deg. cent. Hobert C. Dickinson (Heat Treatment of High Temperature Mercurial Thermometers, Bull. Bur. of Standards, 1906, vol. 2, p. 189) finds that Jena borosilicate glass, though the best glass for high temperature thermometers, must not be used for temperatures much above 500 deg. cent.

COMPENSATION-PLANIMETER BAR WITH SHARP-EDGED ROLLER (*Kompensations-Planimeterstab mit sharfrandiger Rolle*, Generlich. *Zeits. für Dampf-*

kessel und Maschinenbetrieb, May 3, 1912. 3 pp., 6 figs. *e*). Data of tests of J. Schnockel's *compensation-planimeter bar*, and its comparison with Coradi's planimeter and Amsler's polar planimeter. It was found that when used according to the inventor's specification and instructions, the planimeter bar proved to be correct to within less than 1 per cent, and to be comparatively easy to operate. It is claimed that the absence of joints and gear wheel transmissions make it stronger and more lasting.

Mechanics

Hydraulic Drive for Automobiles (*Hydraulischer Antrieb für Motor-Wagen*, A. Heller. *Zeits. des Vereines deutscher Ingenieure*, April 13, 1912. 5 pp., 23 figs. *d*). Description of the Lentz hydraulic drive. Cp. *Motorwagen*, April 20, 1912. A translation of the latter article appeared in the *Automobile*, May 30, 1912.

The Nail (*Le Clou*. Ch. Fremont. *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, February to April 1912. *etA*). The third of a series of articles on the *nail:* investigation of properties, construction, forces acting on, etc. A full abstract will be given when the series is finished in the original.

Law of Similarity Applied to Friction Phenomena (*Das Aehnlichkeitsgesetz bei Reibungsvorgängen*, H. Blasius. *Zeits. des Vereines deutscher Ingenieure*, April 20, 1912, 5 pp., 4 figs. *tA*). A theoretical investigation of the limits of applicability of the physical *law of similarity* to *friction* phenomena. A full account of the investigation will shortly appear in the *Mitteilungen über Forschungsarbeiten*, and an abstract will then be given in *The Journal.*

Note of the Calculation of Cranks and Shafts (*Note sur le calcul des manivelles et des arbres*, Ch. Dekeyser. *Bulletin technique de l'Association des Ingénieurs sortis de l'Ecole Polytechnique de Bruxelles*, April 1912. 20 pp., 8 figs. *mt*). The author starts from Barré de Saint Venant's formula for maximum deformation under combined stresses:

$$Ei > \frac{3t + \sqrt{(5t)^2 + (10\theta)^2}}{8}$$

where E is the longitudinal modulus of elasticity, i maximum permissible deformation, t and θ normal and tangential stresses. He further derives equations for stresses at various points of the crank which, according to his admission, are only approximately correct and too complicated to be used for practical purposes, but which show that for a given position of the crank, various transversal sections of the crank arm are subjected to different stresses, and that the stresses at different points of each section depend on the position of the arm. He proceeds to give a somewhat complicated graphical method for determining whether in a crank of a given longitudinal section and rectangular cross-section there will be points subjected to stresses exceeding the permissible limit.

Sliding Friction (*Über gleitende Reibung*, Charlotte Jacob. *Annalen der Physik*, No. 6, 1912. 22 pp., 13 figs. *etA*.) Physical investigation of *friction between solids*, with special regard to the *relation between friction*

and speed of motion. The author has found that friction depends to a certain extent on the speed, and up to a certain point rises with the speed, at first rapidly, and then slower and slower until it becomes practically constant. For brass a coefficient of friction 0.103 is thus found.

The relation between *friction and temperature* was found to be as follows: as the temperature rises, the angle of friction at first decreases rapidly, becomes constant at about 150 to 190 deg. cent. (302 to 374 deg. fahr.), and at about 250 deg. cent. (482 deg. fahr., all these figures referring to experiments with glass) begins to rise very rapidly. The minimum of the angle of friction at higher temperatures is as low as one-third of that at room temperature. The remarkable fact observed by the author is that, while the relation between the angle of friction and temperature, from room temperature to that corresponding to the minimum, is reversible, it becomes irreversible for the temperature beyond that of the minimum, i. e., the angle of friction retains its high value even after cooling.

Steam Engineering

Latest Data of Tests of Zoelly Steam Turbines (*Neueste Versuchsresultate an Zoelly-Dampfturbinen. Der praktische Maschinen-Konstrukteur*, May 9, 1912. ½ p. e.) Data of tests of several Zoelly turbines of Swiss and German manufacture. The turbines have shown the following steam consumption:

Capacity of Turbine, Kw	R.P.M.	Consumption of Steam, kg/lb.
1,250	3,000	from 5.71/12.6 to 6.71/14.8
5,000	1,500	from 5.42/11.9 to 6.67/14.8
10,000	1,250	from 5.45/11.9 to 6.6/14.7

Water Purification and Elimination of Scale in Boilers (*Über Wasserreinigung und Kesselsteinbekämpfung*, K. Braungard. *Chemiker-Zeitung*, May 9, 1912. 2 pp. *ee.*) Comparison of various methods of *scale elimination*, with special regard to feedwater purification. The author made tests on the efficiency of permutit, and shows that this material may sometimes do a great deal of harm in a boiler. Permutit, like other zeoliths, has the property of giving up only the basic components in exchange for similar components in the alkalis in the water, and in consequence the place of the alkalis is taken by increased amounts of sodium bicarbonate. In boiling water this sodium bicarbonate gives off carbon dioxide according to the formula $2NaHCO_3 = Na_2CO_3 + H_2O + CO_2$, and the soda again breaks up in the boiler, according to the investigations of Blacher and others, into sodium hydrate and carbon dioxide. There is therefore altogether a very large evolution of carbon dioxide which is generally considered a weak and practically harmless gas, but which under conditions present in the boiler attacks the iron just as another dilute acid would do. At the same time the increased alkaline contents of the water attacks the water gage glasses and the packing. The only way to help it would be to let the water off very often, but that involves disadvantages which would destroy all the good that the permutit might otherwise have done.

The author concludes therefore that at any rate dirty water and water containing free carbon dioxide cannot be treated by permutit without being subjected to suitable preliminary processes of purification and deoxidation.

The article contains also a discussion of methods for eliminating iron and manganese from feedwater. (Permutit is a patented product now being introduced in Germany and this country.)

Artificial Draft in Boiler Plants (*Ueber künstlichen Zug bei Dampfkesselanlagen*, H. Hermanns. *Glasers Annalen für Gewerbe und Bauwesen*, May 15, 1912. 3 pp., 4 figs. *d*). General discussion of the advantages of artificial draft in boiler plants, and description of the Schwabach system of induced draft. In this system a fan drives the air through one or more nozzles into a comparatively low smoke stack, and thus produces in the furnace a partial vacuum which may be regulated as required. Tests made by an engineer of the Saxony Association for the Inspection of Boilers with two boilers, one with natural, and the other with induced draft, but absolutely similar in other respects, and handled by the same men, have shown that the cost of producing 1000 kg. (2200 lb.) of steam was in the first case 2.36 marks (say 59 cents), and in the second case (including the cost of driving the fan) 2.26 marks (say 56.7 cents), or a difference in favor of induced draft of 8.5 per cent. The first cost of the Schwabach system of induced draft is said to be much less than that of building a tall smoke stack, besides the fact that in case of transferring the plant from one place to another the smoke stack becomes practically worthless, while the induced draft fan may be moved with very little trouble.

Beluzzo Steam Turbines for Stationary Plants (*Le Turbine a vapore Beluzzo per impianti fissi. L'Industria*, May 12 and 19, 1912. 6 pp., 25 figs. *d*). Description of *Beluzzo stationary steam turbines* (Cp. also *Zeits. des Vereines deutscher Ingenieure*, May 21, 1910). This type has the high, intermediate and low pressure parts quite unlike each other. The high pressure part is in two pressure stages, each with two velocity stages in series, in large units; in small units a single pressure stage and three velocity stages in series. The intermediate pressure part is made of several disks, each with a single blade rim, and each rotating in a separate chamber, the expansion of steam taking place in the distributors of the respective rotors. The low pressure part consists of a drum on which are mounted several blade rings.

Such a turbine is held to possess several important thermal and mechanical advantages. It results, according to the author, in the highest thermal efficiency since, as the pressure and temperature of steam go down, the velocity of efflux from the distributors and the ratio between it and the peripheral speed of the disks also diminish, and this decreases the loss due to friction between the steam and the turbine blades. Further, the arrangement of the high pressure disks in several velocity stages, with minimum expansion in the distributors, permits a rapid decrease in steam pressure between the stages. On the other hand, the drum on the low pressure side makes the rotating part of the turbine more rigid.

The velocity of efflux of the steam from the distributors is 650 to 700 m (say 2100 to 2300 ft.) in the first stage, and 500 m (say 1620 ft.) in the second stage; between 400 and 300 m (1300 to 960 ft.) in the intermediate pressure part, and only about 200 m (650 ft.) in the low pressure part. With such velocities the wear of the blades is practically none.

On coming from the first distributor (Fig. 5), the steam acts on the

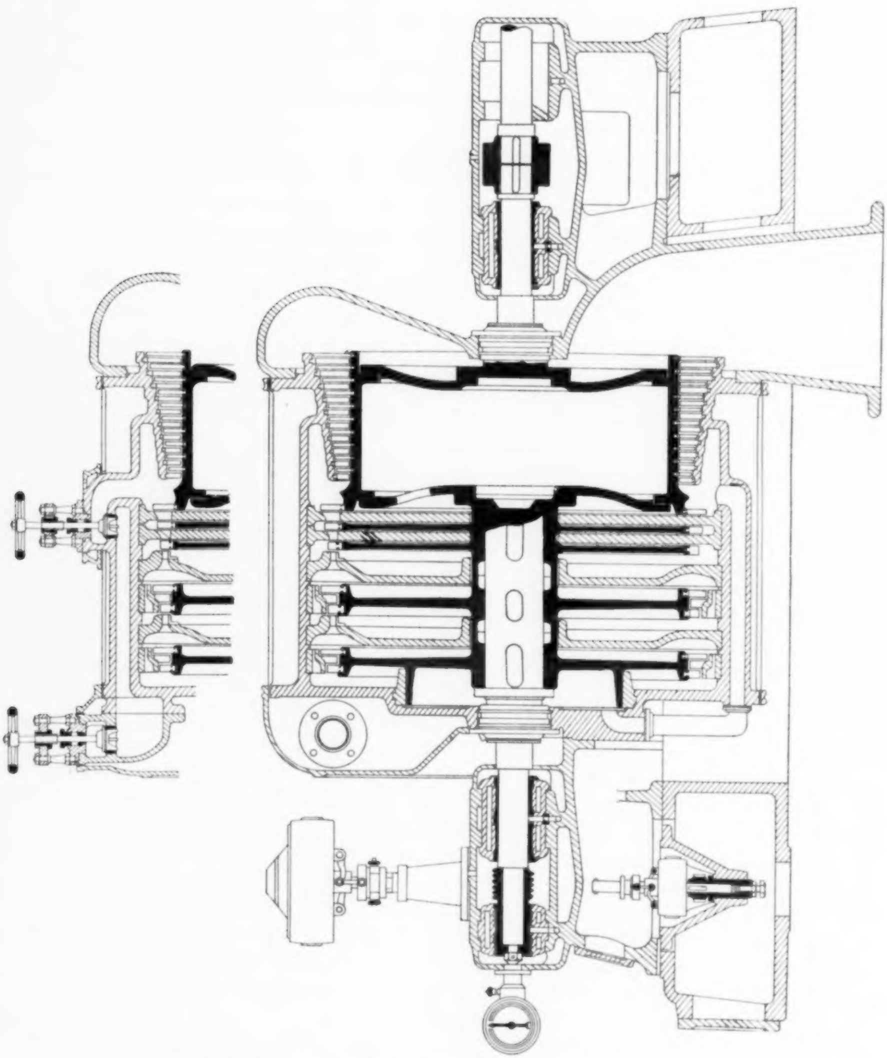

Fig. 5 Belluzzo Steam Turbine for Stationary Plants

blade rim of the first disk, is deflected along the groove in the diaphragm between the two wheels, and enters the distributor of the next wheel. This arrangement prevents the steam from forming eddies when it reaches the distributor of the second wheel, due to the rebound of steam from the first wheel. The first and second wheel have partial admission, and the distributors occupy only parts of the respective peripheries, less than 90 deg. for the first wheel, and a little more than 90 deg. for the second. The intermediate pressure disks have also partial admission, but with a constant angle of about 180 deg. The radial height of blade is thus growing from one disk to another in accordance with the decrease of the velocity of steam and increase of its specific volume. From the last disk of the intermediate pressure section the steam is led to a collector, a sort or receiver between the intermediate and low pressure parts. It has a double duty to perform: in the first instance it distributes uniformly the steam coming from the last disk of the intermediate pressure section.

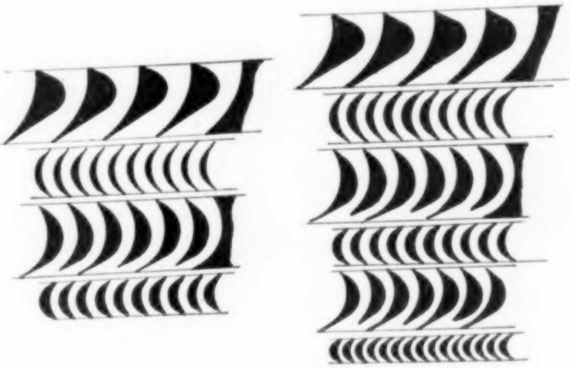

Fig. 6 Distributor and Rotor Construction of the Belluzzo Turbine (Two and Three Velocity Stages in Series)

which has a partial admission, over the drum of the low pressure section having full admission. In the second place it has to maintain the cast iron walls supporting the blades of the distributors of the first wheel at a temperature slightly higher than that of the steam expanding between the disks. Tests made by Professor Belluzzo in 1905 have shown the convenience of such a steam collector. It is of especially great importance for marine turbines in that it prevents the accumulation of water at the bottom of the turbine. Fig. 6 shows the construction of the distributors and rotors. Attention is called to the following: (1) decrease of axial width of the rotor blades from the first disk on to the last; (2) decrease of the peripheral blade pitch; (3) decrease of the angle between the direction of steam, and that of the peripheral velocity; the width of the blades in velocity stages arranged in series is also decreasing. Thereby is gained the great mechanical advantage of having the weight of the blades in various disks, as well as the steam pressure on the blades and the stresses due to centrifugal forces on the various disks, practically uniform.

Evaporation Test of a Double Flue Boiler with Wefer Gas Fired Furnace (*Verdampfungsversuch an einem mit Wefer-Gasfeuerungen ausgerüsteten Zweiflammrohrkessel*, Bütow and Dobbelstein. *Glückauf*, May 18, 1912. 3½ pp., 5 figs. *d*). Description of the *Wefer gas fired furnace*, and data of test of a double flue boiler equipped with it. This furnace is designed to use coke oven gases. Simple nozzles for the admission of the

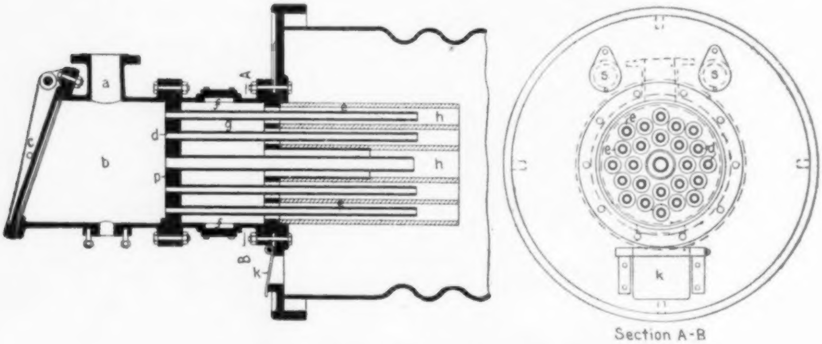

Fig. 7 Wefer Gas Fired Furnace

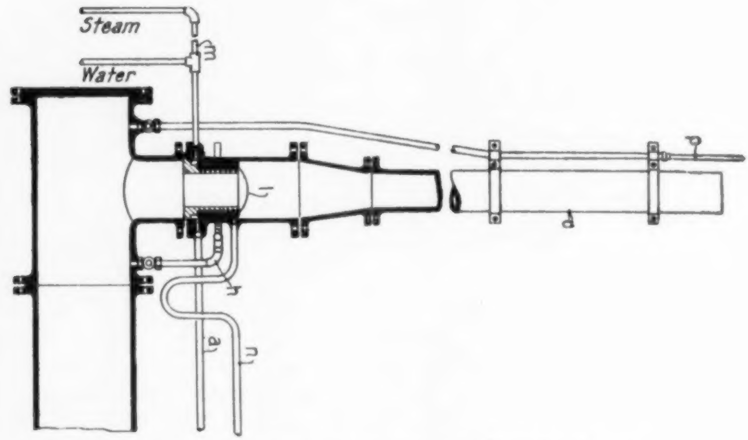

Fig. 8 Wefer Safety Valve for Coke Oven Gas Mains

gas, and admission of air through openings in the flue plate, proved to be unsatisfactory owing to imperfect mixture of gas and air. Terbeck's system proved to be somewhat better, in that it provided for a mixture of the gas and air before ignition, and a supplementary admission of air at the place of ignition, thus insuring a very complete combustion of the gas. This system has, however, a disadvantage in having an explosive mixture formed in the primary nozzles, and that, together with the strongly variable gas pressure in the batteries of coke ovens, leads to frequent small

explosions in the nozzles which not only may injure the furnace, but may, and actually do, cause loss of life and property when starting the fire without due precautions. The Wefer furnace is said to be both efficient and safe. The gas enters through *a* (Fig. 7: to the left is a longitudinal section, to the right cross-section through *A-B*) into chamber *b* provided with a safety lid *c* of such weight that it is not budged by the ordinary gas pressure; should, however, an explosion occur in *b*, the lid is thrown up, and the chamber *b* made wide open. This safety device has been tested several times by artificially produced explosions, and found to be working well. The gases of explosion harmlessly exhaust to the rear of the furnace, the lid falls back in its place, and the furnace continues to work without interruption. From the chamber *b* the gases flow through 25 iron pipes *d*, held by an iron closing plate *p*, to the burners proper *h*. The air enters through the valve *f*, by means of which its admission is regulated, to the air chamber *g*, streams along the gas pipes through the ducts *e*, and mixes with the gas at the ends of the pipes *d*, this mixture being immediately ignited at *h*. The front of the furnace consists of a cylindrical fire resisting piece of graphite into which are led the air ducts *c*. Peep-holes *s* and manholes *k* are provided for inspecting the inside of the furnace, and cleaning the flues.

It was noticed that where there is no gasholder, there is a considerable fluctuation in the gas pressure owing to irregular production of gas by the coke ovens, and that when the gas pressure was above 150 mm. (say 6 in.) of water, there easily occurred small explosions in the furnace. To avoid this a special safety valve (Fig. 8) was installed in the gas main. On the gas pipe is a flanged socket with a cornish double beat valve, with *l* so dimensioned that at a pressure of 150 mm. (6 in.) of water it rises and lets part of the gas out into the outlet pipe *o*, which continues until the pressure falls below the dangerous limit. The gas coming out of *o* is ignited by a small gas flame continually burning at the end of the thin tube *p*. To provide for cases where naphthalin deposits might clog the valve, a hot water supply is installed at *m*, with steam keeping the water at about 80 deg. cent. (176 deg. fahr.), a temperature at which the naphthalin deposits melt; the water is let off through the overflow pipe *n*, placed at the level of the valve head. In order to prevent too rapid cooling of the water in the overflow pipe in winter, the pipe *h*, with holes on the side facing the overflow pipe *n*, is provided: when necessary, a cock is opened, and the gas in *h* ignited, thus making the flow in the overflow pipe *n* certain.

WITTIG ROTARY ENGINES (*Rotierende Machinen System Wittig. Dinglers polytechnisches Journal*, May 4, 1912. 3 pp., 5 figs. *dc*). Description and data of tests of *Wittig rotary engines*. These engines may act either as air or water pumps, or as steam or compressed air engines. Fig. 9 shows the schematic construction of the engine and its mode of operation. At *a*, is an eccentrically placed rotary drum provided with slots in which are placed thin vanes *c*, free to move in and out of the slots, and kept in the position shown by centrifugal force; *k* shows the steam inlet pipe, or air outlet pipe, if the engine is working as a blower. There are several small openings in the casing wall on the left, not shown in the drawing.

TABLE 2 COMPRESSOR FOR COMPRESSION 3 TO 3.5 ATMOSPHERES ABOVE ATMOSPHERIC

Number of Test	1	2	3	4	5	6
R.p.m.	900	900	900	900	900	900
Delivery pressure above atmospheric in atmospheres	4.5	4	3.5	3	2.5	2
Temperature of air at delivery, deg. cent./deg. fahr.	132 269	121 249	112 233	106 222	98 208	92 197
Volume sucked per hr., cbm./cu. ft.	202 7070	215 7525	224 7840	239 8365	256 8960	270 9450
Cooling water per sec., kg./lb.	0.21 0.44	0.21 0.44	0.21 0.44	0.21 0.44	0.21 0.44	0.21 0.44
Temperature of cooling water, deg. cent./deg. fahr.						
(a) entering	9/48.2	9	9	9	9	9
(b) leaving	23.5 74.3	20.5 68.9	19.5 67.1	18.5 65.3	18 64.4	17.5 63.5
Heat carried away by cooling water per sec., WE/b.t.u.	3.05 12	2.42 9.6	2.2 8.7	2.05 8.1	1.9 7.55	1.78 7.05
Power consumption, h.p.	27.5	23.3	21.7	20.9	19.8	18.9
Heat carried away by the air per sec., WE/b.t.u.	1.78 7.05	1.68 6.7	1.62 6.43	1.63 6.45	1.5 5.97	1.55 6.18

Barometer, 720 mm.
Room temperature, 17 deg. cent. or 62.6 deg. fahr.

TABLE 3 TEST OF STEAM ENGINE

Number of Test	1	2	3	4	5
Pressure of entering steam above atmospheric.	9.45	9.4	9.4	9.35	...
Temperature of steam, deg. cent./fahr.	245 473	230 446	250 482	220 428	200 392
R.p.m.	1490	1490	1490	1490	1500
B.h.p.	10.52	10.52	10.75	10.68	0
Consumption of steam per h.p-hr., kg./lb.	16.6 36.2	17 37.4	16.2 35.6	17.5 38.5	... ...

When the engine is working as a blower or exhauster, the cells formed by the vanes *c* pass these openings as the size of the cells increases owing to the eccentricity of the drum, and expel the air; from the top of the engine, where the cells reach their maximum, they travel for some time without meeting any openings, and tend to compress the air inside them which they discharge through *k* when they reach it. If the machine works as a motor, either steam or compressed air, the driving fluid, which will be called steam hereafter, enters from *k* into the cells opening into it, say into z_1. At the start rotation is produced by the pressure of the steam against the whole area of the foremost blade of cell z_1. As regards the enclosed cells, z_2, the author explains that there is a difference of pressure on the vanes, because the vane foremost in the direction of rotation projects further, and therefore presents a larger area to the steam pressure than the vane further back: the difference in pressures will therefore tend to drive the whole piece in the direction of rotation. The total force

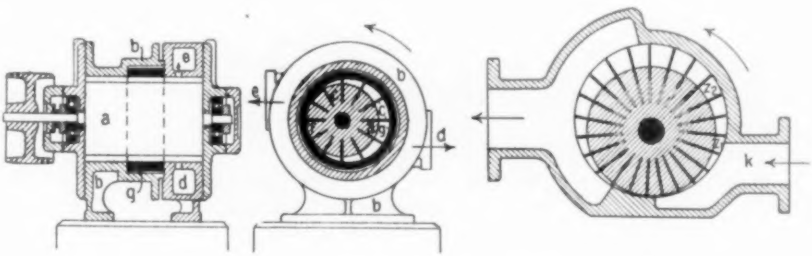

FIG. 9 WITTIG ROTARY ENGINE

driving the engine is proportional to the sum of the differential pressures in the cells to the right of the figure, the exhaust openings being on the left, where the cells begin to grow smaller.

The use of a large number of vanes and cells, and the arrangement by which these cells can grow larger and smaller, is said to present the following advantages: (*a*) There are no valves necessary, the admission and exhaust being effected through uncovered openings, and compression and expansion regulated by the cells changing their size automatically. (*b*) The difference in size between two contiguous cells being slight, the difference in pressure is also small, and therefore the vanes are subjected to comparatively small stresses, and leaks from one cell to another are small as well. (*c*) At *f*, where the drum comes nearest to the casing, and where in an air compressor there would be especial need of packing to divide the suction space from compression, in this machine there is no need of packing at all, because there is always at least one vane *c* to separate the two chambers. (*d*) Since the cells are filled or emptied in rapid succession, there is a practically uniform flow of steam or air both into or out of the engine, as well as a uniform turning moment on the shaft.

If, however, the vanes were allowed to press against the casing, there would be a considerable friction between them. To prevent this, there

are provided collars g having nearly the same inside diameter as the casing, and arranged so that they have a certain play both normally to the axis and sidewise. They are carried away by the vanes with them in their rotary movement, and enclose the vanes like hoops around a barrel, the casing proper serving only as a guide to this revolving system. When in contact with the collar, each vane is drawn somewhat sidewise owing to the eccentricity of the slot with respect to the axis of the casing. This eccentricity is, however, of advantage in diminishing the friction losses.

In Tables 2 and 3 are data of tests of a Wittig air compressor and a Wittig 10-h.p. engine receiving steam at 10 atmospheres above atmospheric pressure with exhaust into the atmosphere.

Ljungström Reaction Steam Turbine (*La turbine à vapeur à réaction, système Ljungström*, F. D. *Le Génie Civil*, May 18, 1912. 3 pp., 13 figs. and a sheet of drawings). Description of the Ljungström reaction turbine. For a complete description of this turbine see *Engineering*, April 12, 1912.

Thermodynamics

The Joule Cycle (*Sur le cycle de Joule. Comptes Rendus de l'Académie des Sciences*, April 22, 1912. 2 pp. *t*). Some investigators have pointed out that pressure plays a more important part in internal combustion motors than temperature, and that these motors might be better investigated on the basis of the Joule cycle, between the same limits of pressure as the motor, than on that of the Carnot cycle. It becomes therefore of importance to find out under which general conditions this cycle may be substituted for the Carnot cycle.

In the first place, for the given gaseous body, the efficiency of the Joule cycle must be a function of only the extreme pressures.

If now $G(p, S)$ is the thermodynamic potential of a fluid expressed in terms of variables p, S (pressure, entropy), G cannot be any function, but must have the special form

$$G(p, S) = f(p)h(S) + g(p)$$

where $f(p)$ is a positive and increasing function of p, and $h(S)$ is an increasing function of S.

This being the thermodynamic potential, and $A = \frac{1}{E}$ the reciprocal of the mechanical equivalent of heat, the internal heat U, absolute temperature T, and specific volume v will have the following values:

$$U = [f(p) - pf'(p)]h(S) + g(p) - pg'(p), \quad T = f(p)h^1(S)$$

$$v = E[f'(p)h(S) + g'(p)]$$

while the caloric efficiency of the Joule cycle, between the pressures p_o, $p_1 > p_o$

$$p = \frac{f(p_o)}{f(p_1)}$$

These conditions are necessary and sufficient in order that the Joule cycle should have the same properties as the Carnot cycle, when the pressures instead of temperatures are considered. The Joule cycle *may* there-

fore be applied even when the mixture is not considered equivalent to a perfect gas.

Supplementary References

Characteristic curves of Diesel motors (Foreign Review, June 1912, p 958). Complete translation of the article in the *Automobile*, May 16, 1912.

The Aphegraphe (Foreign Review, January 1912, p. 124). Cp. description in the *Engineering Record*, May 25, 1912, p. 570.

The Emperger system of "strapped" or spirally reinforced cast-iron-concrete construction (Foreign Review, April 1912, p. 636, and May 1912, p. 805). Cp. account of same (9 pp., 12 figs.) in *Concrete and Constructional Engineering*, London, June 1912, p. 423.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XIX)

ARTICLES IN PERIODICALS[1]

COKE OVEN GAS, EXTENSIVE USE OF, C. O. Tupper. *Power*, May 21, 1912. 3½ pp., 5 figs., 2 tables. *cd.*

Composition of gases; gas engine driven electric plants; combined gas engine and steam turbine systems; power equivalent of coke oven gases; by-product recovery plants.

DIESEL ENGINES, CRANKSHAFTS FOR. *Engineering*, May 31, 1912. 2-3 p. *m.*

Discussion of formulæ for crankshaft design.

DIESEL ENGINE, PRESENT STATUS OF THE. *Power*, May 28, 1912. 3 pp., 7 figs., 1 curve. *cdh.*

Early history; commercial types marine engines; Diesel locomotives.

GASTURBINE, DIE, A Stodola, of Zurich. *Zeitschrift des Vereines deutscher Ingenieure*, March 30, 1912. 3¼ pp., 2 tables, 3 curves. *cmp.*

Review and criticism by Professor Stodola of the book of that title by Hans Holzwarth.

INTERNAL COMBUSTION ENGINES, EXHAUST GAS CALORIMETERS FOR, J. S. Nicholson and T. B. Morley. *Engineering*, May 31, 1912. 1 p., 3 figs. *dm.*

Describes apparatus for sampling and analysis of exhaust gases.

MOTOR PASSENGER LAUNCH "VIOLETA." *Engineering*, May 31, 1912. 1½ pp., 6 figs. *d.*

Describes power equipment consisting of two four-cycle petrol paraffin engines of 80 h.p. each.

TREBERT GASOLINE ENGINE, THE. *Power*, June 4, 1912. 1½ pp., 2 figs. *d.*

Describes a six-cylinder four-stroke cycle engine for aeroplanes.

WASSERGAS, EINRICHTUNG UND BETRIEB VON. HALBWASSERGAS UND SAUGGASANLAGEN. *Kraft*, March 21, 1912. 1⅛ pp. *p.*

Certain basic principles for the arrangement and operation of water-gas, semiwater (Dowson) gas and suction gas plants.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The last regular meeting of the Armour Student Branch took the form of a banquet at the Boston Oyster House on May 15, A. J. Beerbaum being toastmaster. Following are the speakers of the evening: Professor Gebhardt, Mem. Am.Soc.M.E., spoke of the importance of keeping in touch with one's Alma Mater; Professor Frith, Mem.Am.Soc.M.E., The Future of the Gas and Gasolene Engines; Professor Coffeen, The Value of a College Course in the Business World; Professor Perry, who was a member of the first graduating class, told of the early days at Armour. E. R. Burley, the newly elected chairman, gave his plans for making the coming year a successful one.

LEHIGH UNIVERSITY

The last meeting of the year of the Lehigh University Student Branch was held May 16, when Calvin W. Rice, Secretary of the Society, told the students of the need of branch societies to encourage scientific discussion, and also what results are to be derived by affiliation with The American Society of Mechanical Engineers.

CORNELL UNIVERSITY

At a meeting of the Sibley College Student Branch, held May 4, Mr. Johnson, president of the Baldwin Locomotive Works, addressed the students on the fallacies of some present-day notions of success.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On May 13 the Mechanical Engineering Society was addressed by Charles T. Main, Mem.Am.Soc.M.E., on the Commercial Efficiency and Special Uses of Power Plants. Many points were brought up in the discussion which were of special interest to those students taking the mill engineering option at the institute.

PURDUE UNIVERSITY

At a meeting of the Purdue University Student Branch on April 17, L. W. Wallace of the School of Mechanical Engineering, read a paper on the Efficiency in Railway Management. On May 15, C. B. Veal, Mem.Am.Soc.M.E., spoke on Aerial Engineering.

UNIVERSITY OF CINCINNATI

At a meeting of the University of Cincinnati Student Branch, held May 17, Mr. Pollard, mechanical engineer of the Cincinnati Water Works, delivered an illustrated lecture on the History and Development of the Cincinnati Water Works System.

NECROLOGY

HENRY S. ROBINSON

Henry S. Robinson was born at Meredith, N. H., January 22, 1831, and died April 4, 1912. After completing what was at that time considered to be a good academic education, he took up the active duties of life in 1847 as assistant engineer of the Hamilton Manufacturing Company at Lowell, Mass., and later became consulting engineer for the same company. In 1849 he went to the York Mills at Saco, Maine, as chief engineer, where he remained six years. From 1855 until 1861 he and his brother, James R. Robinson, were in business at Clinton, Mass., as consulting steam engineers. During the Civil War he served for a short time as assistant engineer in the Navy and later in the Army as lieutenant in the 36th Regiment of Massachusetts. From 1865 until 1873 he had charge of the steam plant at the Pacific Mills, Lawrence, Mass., and in 1873 engaged in the business of boiler manufacturing at Boston, at the same time acting as consulting engineer for many of his former clients. In 1892 he retired from active business and allied himself with The Atlantic Works, Boston, of which company he was vice-president from 1892 until 1898, and president from 1898 until his death.

From an engineering standpoint, Mr. Robinson's life was particularly noteworthy for the practical results which he achieved in improving methods of steam boiler construction and operation, and in convincing his clients and customers of the desirability on economic grounds, and duty for humanitarian reasons, to design, construct and operate steam boilers with a careful and intelligent regard for the natural laws affecting them. Before his death he had the satisfaction of knowing that methods which he had advocated and practised many years before were being quite generally adopted by engineers and boiler manufacturers, and in some particulars were being required by legislative regulations.

JOHN T. HAWKINS

John T. Hawkins was born in Abingdon, England, December 22,

1828. When eight years of age he came to America and attended the public schools of New York City. His first employment was with Hoe & Company, printers, with whom he remained until July 1861, when he joined the Navy as third assistant engineer. For efficiency of service he was promoted to a chief engineer's berth, in which capacity he served until the close of the war. He was present at the attacks on Forts Jackson and St. Phillips, the capture of New Orleans and many less important engagements. The following four years he taught engineering chemistry and physics at the United States Naval Academy at Annapolis, and then together with George R. Holt, another naval officer, resigned from the service and engaged in spool making at Salisbury, Vt. His next connection was with the Campbell Printing Press and Manufacturing Company, Taunton, Mass., of which he became president and was in entire charge of the mechanical part of the business. During this period he made many improvements on printing machinery and had taken out over fifty patents on his inventions. In 1897 he became consulting engineer for the Crown Cork & Seal Company, Baltimore, Md., and three years later retired from active business. He died April 29, 1912.

REPORT OF MEETING

BOSTON MEETING, MAY 26

The American Institute of Electrical Engineers held a meeting at the Harvard Union, Harvard College, Cambridge, Mass., on May 26, at which the American Society of Civil Engineers and the Society coöperated. Following the inspection of the engineering laboratories in Pierce Hall, supper was served in the Union, and Professor Hollis, Mem.Am.Soc.M.E., opened a discussion on the field for the low-pressure turbine. He spoke at length of some installations which had come especially under his observation, and gave his views as to the field for such a machine. Others taking part in the discussion were: S. A. Moss, Mem.Am. Soc.M.E.; G. H. Diman, Mem.Am.Soc.M.E.; F. H. Hayes, Mem.Am.Soc.M.E.; W. G. Starkweather, Mem.Am.Soc.M.E.; C. A. Read, Mem.Am.Soc.M.E.; A. E. Kennelly, N. J. Neall, F. N. Gunby and others.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0173 Instructor in steel works engineering, design of mill machinery and furnaces, wanted by engineering school in western Pennsylvania. Technical graduate with at least six years of practical experience preferred. Excellent opportunity for right man.

0174 Consulting factory management expert, desires to negotiate working agreement or co-partnership with gentleman equally qualified in the organization and management of sales departments.

0175 Company manufacturing hoisting and conveying machinery located in the Middle West, desires young man with knowledge of shop management and wage systems, also experience in machine shop. Give full details of experience, positions held, references and salary accepted to start. Permanent position in good locality assured the right man. Apply through Am.Soc.M.E.

0176 Company manufacturing electric cranes, wants experienced designing engineer, one high-class structural draftsman and one general detail draftsman. Applicants must give full information as to former positions, experience and salary expected. Apply through Am.Soc.M.E.

0177 Wanted for plant in vicinity of Philadelphia, young or middle-aged man to carry out under direction, the details of a cost and follow-up system, as well as arrangement of new machinery. Salary dependent largely on incumbent and at rate from $1500 to $2500.

0178 Young designing engineer wanted on high-speed automatic steam engine design; experience in four-valve engines. Salary $1000 to $1200.

0179 Assistant superintendent leading to position of superintendent. One familiar with gas engine and gas tractors, with at least five years' experience and from 35 to 40 years of age; familiar with modern shop practice and scientific management, capable of organizing and good executive ability. Salary to start $200 a month.

0180 Competent mechanic to take charge of new shop. Must be thoroughly

experienced in quantity production in sheet metal, including press work, drawing and spinning, and experience in handling men. Prefer man experienced in manufacture of light steel sheet metal boxes, stamping and making seamless cans; enameling sheet steel. State age, references and salary expected. Location near New York. Apply through Am.Soc.M.E.

0181 Active man in sales engineering department, to handle feedwater domestic service, heating system heaters and expansion joints, in and about vicinity of New York City. Technical graduate with engineering experience along power plant line, having acquaintance with architects and engineers, and general engineering trade preferred. Apply through Am.Soc.M.E.

MEN AVAILABLE

446 Junior, technical graduate, age 29, married; experienced in motor car design and manufacture, desires permanent connection with concern producing pleasure or industrial motor cars. Now holds position of chief engineer with established motor car company.

447 Chief engineer or superintendent of large power plant or number of smaller ones. Experienced in railway and lighting, also construction work.

448 Position as chief draftsman, sales engineer or assistant manager, wanted by engineer with broad experience in design of boilers and general steel plate construction. Location in or near Baltimore, Philadelphia or New York preferred.

449 Works manager, competent to organize all departments of manufacturing plant along modern lines, long experience on light manufacturing, involving interchangeable parts.

450 Junior, six years' experience in power plant and fuel engineering work, desires position with engineering or contracting firm in design or construction.

451 Member, electrical and mechanical engineer having office in high-class office building and advantageous business connections, desires to represent manufacturer as agent in Chicago in connection with engineering practice.

452 Five-thousand dollar man, is desirous of obtaining a position as chief engineer, consulting engineer or shop manager. Wide experience in steam and hydraulic engineering. Unsurpassed references. Location in or near New York City.

453 Junior, thoroughly acquainted with steam machinery, and selling conditions; exceptional experience in agency and territorial agreements, will consider opening as sales manager or assistant at salary and commission. Write care of Am.Soc.M.E.

454 Competent executive, 36 years of age, eight years' experience as manager and superintendent of industrial plants, desires position; broad experience in engineering lines, machine shop practice, organizing and systematizing; yearly remuneration during past five years averaged $5000 per year.

455 Member with extensive experience in large machine and tool manufacturing plants from finest and most accurate classes of precision work to the heaviest; thorough practical knowledge of tools, machinery, equipment, modern shop practice organization and management, seeks connection as superintendent, master mechanic or factory manager. Salary not less than $3000, and can earn more.

456 Mechanical engineer, as plant engineer or engineering general assistant. Maintenance and construction buildings, power and miscellaneous equipment, safety fire protection and transportation systems, experimental, testing and inspection departments; railroad government and factory experience.

457 Mechanical graduate, age 34, wishes to change; as general testing and inspection engineer, mechanical, electrical, construction, materials, for responsible service.

458 Junior, technical graduate, with nine years' practical experience covering building construction and superintendence, machine and structural design, plant installation and improvements, the design of concrete handling plants and appliances, desires position as mechanical engineer or assistant to consulting engineer. Location New York or vicinity. Salary $2000.

459 Member desires change of location, with nine years' teaching experience in technical subjects, and four years' practical experience, desires position in the East as designing engineer where some inventive ability is required. Can design and superintend the building of automatic machines for turning out special work in quantity. Would consider teaching position in drawing, descriptive geometry or kinematics of machines.

460 Graduate mechanical engineer, with extensive experience in manufacturing interchangeable machinery. Specially good experience in the design of machinery, jigs, and fixtures for the production of duplicate parts, also in testing, handling and use of glues and adhesives. Now mechanical engineer with large wood and iron working factory; wishes position as superintendent.

461 Junior, technical graduate, 31 years of age, married, with six years' experience in general machine shop work, six years' in power house design and construction and a thorough knowledge of modern tools, equipment, shop methods and management, desires position as superintendent with growing concern. At present, chief draftsman for power house engineers and contractors.

462 Member, mechanical engineer, power house design, heating, ventilating, etc. Best of references, open for engagement.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

Die Abwärmeverwertung im Kraftmaschinenbetrieb, Ludwig Schneider. ed. 2. *Berlin, 1912.*

American Practice in the Rating of Internal Combustion Engines, T. C. Ulbricht. *1912.* Gift of the author.

The American Society of Mechanical Engineers. Yearbook, 1912. *New York, 1912.*

American Society of Swedish Engineers. List of Members, May 1, 1912. *Brooklyn, 1912.*

American Telephone & Telegraph Company. Annual Report of the Directors to the Stockholders, 1911. *New York, 1912.* Gift of the company.

Bau und Betrieb von Kältemaschinenanlagen, C. Heinel. *München,* 1906.

A Book of Portraits. Containing photographs of 564 of the 1500 contributors to the Encyclopaedia Britannica. *New York.* Gift of Encyclopaedia Britannica Company.

Central Station Heating, B. T. Gifford. *New York, 1912.*

Cold. Vols. 1-2, vol. 3, nos. 1-7. *Calcium, 1909-1912.* Gift of Madison Cooper Co.

Concrete Costs, F. W. Taylor and S. E. Thompson. *New York, J. Wiley & Sons, 1912.*

Tables and recommendations for estimating the time and cost of labor operations in concrete construction and for economical methods of management. The information given in the tables as to how long workmen should take to do all kinds of tasks, has been obtained by watching one man after another while he was doing a day's work, and noting with a stop-watch the time taken in doing each small element of the trade.

The immense amount of labor involved in getting together the data for this work is evident from the statement in Mr. Taylor's introduction, where it is stated that Mr. Thompson and his assistants have spent seventeen years in a minute, painstaking study of the building trades, and this is the first book resulting from this work, which deals with the time and cost problem. Works are promised on earth work; bricklaying; lathing; plastering; carpentry; slating, and many of the smaller trades. It is certain that this work will be looked on in the future as foreshadowing a new era for the workman, as well as for the contracting employer.

Mr. Taylor says: "It is our firm conviction that the introduction of the principles of scientific management into this field will produce the same beneficent results that have been secured elsewhere: that high wages earned by the workman and a low labor cost secured by the employer will convince both sides that it is for the interest of each to have the welfare of the other at heart; that friendly co-opera-

tion is better than suspicious watchfulness or open antagonism; that peace is better than war And if this book helps in bringing about this result it will have fulfilled its most important object."

CONGRESO CIENTIFICO (1o PAN AMERICANO) CIENCIAS NATURALES, ANTROPOLOGICAS Y ETNOLOGICAS. Vol. 2. *Santiago de Chile, 1911.* Gift of the congress.

CONGRESO CIENTIFICO (1o PAN AMERICANO) AGRONOMIA Y ZOOTECNIA. Vol. 15. *Santiago de Chile, 1911.* Gift of the congress.

ELEMENTARY MECHANICAL REFRIGERATION. A Simple and Non-technical Treatise, F. E. Matthews. *New York, 1912.*

ENCYCLOPAEDIA BRITANNICA. ed. 11, vols. 1-29. *Cambridge, 1910.*

ENGINEERING SOCIETY OF WISCONSIN. Proceedings of 3d Annual Convention, 1911. *Madison, 1911.* Gift of the society.

DAS FLUGZUG FÜR DIE KRIEGSMARINE UND DEN WASSERSPORT, THEORIE UND PRAXIS IM BAU DER WASSERFLUGZEUGE (UND GLEITBOOTE), K. F. M. Rösner. *Berlin, 1912.*

FORSCHERARBEITEN AUF DEM GEBIETE DES EISENBETONS. pt. 18. *Berlin, 1912.*

UEBER GRUNDLAGEN FÜR DEN BAUVONKRAFT-WAGEN, Dr. Hofmann. *Berlin, 1912.*

HJORTH, SOREN. Inventor of the Dynamo-electric Principle, Sigurd Smith. *Kobenhavn, 1912.*

INTERNATIONAL CONGRESS OF REFRIGERATION (2d), Vienna. English edition. 1910. *Vienna, 1911.*

LEHRBUCH DER THERMOCHEMIE UND THERMODYNAMIK, Otto Sackur. *Berlin, 1912.*

DER LUFTWIDERSTAND UND DER FLUG, G. Eiffel. *Berlin, 1912.*

MITTEILUNGEN ÜBER VERSUCHE AUSGEFÜHRT VOM EISENBETON-AUSSCHUSS DES ÖSTERREICHISCHEN INGENIEUR UND ARCHITEKTEN VEREINS. Vol. 1, 2. *Leipzig, 1912.*

MOTORWAGEN UND FAHRZEUGMASCHINEN FÜR FLÜSSIGEN BRENNSTOFF, A. Heller. *Berlin, 1912.*

NATIONAL ASSOCIATION OF RAILWAY COMMISSIONERS. Proceedings of 23d Annual Convention. *Chicago, 1912.*

EINE NEUE VERWENDUNG DES GUSSEISENS BEI SÄULEN UND BOGENBRÜCKEN, F. von Emperger. *Wilhelm Ernst & Sohn. Berlin, 1911.*

Attention has been called to Dr. Emperger's "strapped" concrete in the Foreign Review of THE JOURNAL (April, 1912, p. 636). This system consists in covering a cast-iron member by a concrete jacket strapped all around by a wire helix. The cast-iron member may be either a solid column, or a hollow tube. The present pamphlet, written by the inventor of this system, who is also editor of *Beton und Eisen*, contains numerous data of tests of strapped concrete and rules for the design of columns, as well as the principles of design of arched bridge members in strapped concrete-iron tubes. The advantages claimed for the Emperger system of construction are that it adds to the toughness of the cast iron, and makes the concrete construction more reliable.

NEW JERSEY PUBLIC UTILITY BOARD. Annual Report, 2d, 1911. *Trenton, 1913.* Gift of the board.

NEW YORK CITY BOARD OF WATER SUPPLY. Contract 132. Borings on and near the site of the proposed Silver Lake reservoir, 1912. Gift of the board.

PHÉNOMÈNES THERMIQUE DE L'ATMOSPHÈRE, Emile Schwoerer. *Paris.* Gift of the author.

POLYTECHNIC ENGINEER. Vol. 12, 1912. *Brooklyn, 1912.* Gift of Polytechnic Institute of Brooklyn.

PRESS REFERENCE LIBRARY (Southwest Edition). Notables of the Southwest. *Los Angeles, 1912.* Gift of Los Angeles Examiner.

RAPPORT SUR UN MÉMOIRE DE M. EMILE SCHWOERER INTITULE "LES PHÉNOMÈNES THERMIQUES DE L'ATMOSPHÈRE," M. E. Bouty. *Paris, 1910.* Gift of E. Schwoerer.

REFRIGERATION, COLD STORAGE AND ICE MAKING, A. J. Wallis-Tayler. ed. 3. *New York, 1912.*

REINFORCED CONCRETE BUILDINGS, E. L. Ransome and Alexis Saurbrey. *New York, 1912.*

ROBINSON, STILLMAN WILLIAMS. A Memorial. *Columbus, Ohio State University, 1912.* Gift of Ohio State University.

ROTOR EIN DEUTSCHER ROTATIONS-FLUGMOTOR, F. Hansen. *Berlin, 1912.*

SANITARY PROBLEMS OF THE BOARD OF WATER SUPPLY, A. J. Provost, Jr. (Reprint from Municipal Engineers of the City of New York, 1911.) Gift of the author.

SELBSTKOSTENBERECHNUNG GEMISCHTER WERKE DER GROSSEISEN-INDUSTRIE. H. Wagner. *Berlin, 1912.*

SPEED AND POWER OF SHIPS, D. W. Taylor. Vols. 1-2. *New York, 1911.*

SPERRY GYRO-COMPASS AND NAVIGATION EQUIPMENT. *New York, 1912.* Gift of Sperry Gyroscope Company.

DIE SPEZIALSTÄHLE, G. Mars. *Stuttgart, 1912.*

SWEDISH ENGINEERS' SOCIETY OF CHICAGO. Year Book 1911, 1912. *Chicago, 1911-1912.* Gift of society.

DAS TROCKNEN UND DIE TROCKNER, Otto Marr. *München, 1910.*

TWELVE PRINCIPLES OF EFFICIENCY, Harrington Emerson. *New York, 1912.*

VALUATION OF PUBLIC UTILITY PROPERTIES, Henry Floy. *New York, McGraw-Hill Book Co., 1912.*

The author has been engaged for several years in valuing property aggregating hundreds of millions of dollars. A similar work by Horatio A. Foster was issued at about the same time. The valuation of public utilities has become an important part of the plans for the regulation of public service corporations, and the appearance of these volumes is especially timely. The discussion of the vexed question of depreciation is particularly full.

WALWORTH-ENGLISH-FLEET COMPANY. "1912 U. S. Standard" schedule of standard weight and extra heavy flanged fittings and flanges. *Boston, 1912.* Gift of the company.

ZEITSCHRIFTENSCHAU DER GESAMTEN EISENBETONLITERATUR 1911, R. Hoffmann and A. Fitzinger. *Berlin, 1912.*

DIE ZWISCHENDAMPFVERWERTUNG IN ENTWICKLUNG, THEORIE UND WIRTSCHAFTLICHKEIT, Ernst Reutlinger.

GIFT OF MR. E. B. RENWICK

The Society wishes to thank Mr. E. B. Renwick for a large number of interesting books and pamphlets which he has placed at the disposal of the United Engineering Society Library.

UNITED ENGINEERING SOCIETY

INVESTIGATION OF THE ECONOMY OF A SIMPLE ENGINE OPERATING WITH STEAM LESS THAN THAT OF ATMOSPHERIC PRESSURE, R. C. Carpenter. Gift of the author.

KENTUCKY AGRICULTURAL EXPERIMENT STATION OF THE STATE UNIVERSITY. Bull. No. 154. Blowing Stumps with Dynamite. *Lexington, 1911.* Gift of the agricultural experiment station.

MANUALS OF SAFETY, YARD PRACTICE, WALKS AND RAILINGS, Chas. Kirchhoff and W. H. Tolman. *New York, 1912.* Gift of American Museum of Safety.

MOODY'S MANUAL OF RAILROADS AND CORPORATION SECURITIES. ed. 13, 1912. *New York, 1912.*

NATIONAL WATERWAYS COMMISSION. Final Report. *Washington, 1912.* Gift of the Commission.

RULES OF PRACTICE IN THE UNITED STATES PATENT OFFICE. Revised July 17, 1907. *Washington, 1912.*

TITANIC DISASTER. Report of the Committee on Commerce United States Senate. *Washington, 1912.* Gift of Senator W. A. Smith.

TREATISE ON HYDRAULICS, Mansfield Merriman. ed. 9. Revised and rewritten with the assistance of Thaddeus Merriman. *New York, J. Wiley & Sons, 1912.*

This well-known work appears in a new dress, with much new matter. Nearly ten years have elapsed since the last complete revision, and now the book contains the results of the work of the last decade. Of the several editions of this work, 37,000 copies have been printed, the first edition being issued in 1889. The great increase in the development of the water power plants in the country emphasizes the importance of a thorough revision of this standard work.

SWITZERLAND—PATENTE JAHRES-KATALOG XXIII JAHRGANG, 1911. Brevets. Catalogue Annuel XXIIIme Année, 1911. *Brugg, 1912.*

WHO'S WHO IN AMERICA. 1912-1913, vol. 7. *Chicago, 1912.*

EXCHANGES

AMERICAN GAS INSTITUTE. Proceedings. 1911, pts. 1-2. *New York, 1912.*

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. Transactions. vol. 16. *New York, 1910.*

INSTITUTION OF MECHANICAL ENGINEERS. List of Members, March 1, 1912. *London, 1912.*

WESTERN SOCIETY OF ENGINEERS. Year Book, 1912. *Chicago, 1912.*

TRADE CATALOGUES

ALBERGER PUMP CO., *New York.* Alberger centrifugal pumps and steam turbines, 71 pp.

AMERICAN BLOWER CO., *Detroit, Mich.* Bull. no. 330, "Ventura" disc ventilating fans, 19 pp.

S. F. BOWSER & CO., *Fort Wayne, Ind.* Bowser oil filtration and circulating systems, 28 pp.

BRISTOL CO., *Waterbury, Conn.* Bristol's recording gages for pressure and vacuum, 63 pp.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.* Ball bearings in wood-working machinery, 31 pp.

HEWITT MOTOR CO., *New York.* Hewitt trucks, 42 pp.

IDEAL CASE HARDENING COMPOUND CO., *New York.* Case hardening, pack hardening, annealing with ideal compound, 20 pp.

M. W. KELLOGG CO., *New York.* Fire welding of pipe flanges and nozzles, 12 pp.

J. E. LONERGAN CO., *Philadelphia, Pa.* Boiler steam and gas engine fittings, 63 pp.

THE LUNKENHEIMER CO., *Cincinnati, O.* Brass and iron valves, lubricators, oil pumps, motor accessions and machine supplies, 654 pp.

W. M. MATTHEWS & BROS., *St. Louis, Mo.* Supplies for telephone, light, railway and general electric use, 152 pp.

MID-WESTERN CAR SUPPLY CO., *Chicago, Ill.* Anderson friction draft gear, 12 pp.

MORSE, WILLIAMS & CO., *Philadelphia, Pa.* Hudley worm gears and spirals, 110 pp.

SIEMENS & HALSKE, *Berlin.* Frahm vibration tachometer, 8 pp.

THOMSON ELECTRIC WELDING CO., *Lynn, Mass.* Electric welding machines, 72 pp.

WELLINGTON MACHINE CO., *Wellington, O.* Brick machinery, 52 pp.

WESTINGHOUSE ELECTRIC & MFG. CO., *East Pittsburgh, Pa.* Circular No. 1099A, Westinghouse turbo-alternators, 36 pp.

WESTON ELECTRICAL INSTRUMENT CO., *Newark, N. J.* Miniature precision direct-current instruments, 31 pp.

HENRY R. WORTHINGTON, *New York.* Outside packed plunger pattern pumps, 40 pp.

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